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# Frogs of the Genus *Physalaemus* in Southern Brazil with the Description of a New Species

WILLIAM W. MILSTEAD

THE genus *Physalaemus*, which Noble (1931) thought was near the basal stock of the family Leptodactylidae, comprises a group of widespread and poorly understood species. The striking parallelisms and polymorphisms that have developed among them have caused much confusion in the literature. Complete or partial revisions have been published by Miranda-Ribeiro (1926), Parker (1927), and Cochran (1955), but these have not clarified the most difficult taxonomic problems chiefly because of inadequate field data.

While at the University of Rio Grande do Sul in Pôrto Alegre, Brazil (Oct., 1953, to July, 1955), I had an opportunity to study certain species of *Physalaemus* in the field. Although my data are not sufficient to define all of the species in the genus, they are adequate to define the five species living in what I consider a critical area. Rio Grande do Sul contains the type localities of three species of *Physalaemus* and is, therefore, important to any study of the genus. While most of my data were drawn from specimens collected in this state, the conclusions are for the most part applicable to adjacent states as well.

Rio Grande do Sul is a transition zone between the treeless pampas and the heavily forested Brazilian Highlands and between the timbered coast and the pampas. The Brazilian Highlands come into Rio Grande do Sul in the northern portion of the state; the coastal timber belt is present in the northeast; and the pampas enter the state from the southwest. The central portion of the state is an area of low elevation, known as the Depressão Centrál, and represents a more or less equal blending of forests and pampas. It consists of rolling grasslands with scattered patches of forest that are so dense that little sunlight reaches the forest floor. These stands of forest do not, however, have the epiphytes characteristic of the northern and coastal forests. Most of the field study of *Physalaemus* was done in the central depression and in the coastal belt. Some work, however, was done in all other regions of the state except the extreme south.

Mello-Leitao (1942) recognizes only one biotic province, the Guarani province, in Rio Grande do Sul, while Cabrera and Yepes (1940) recognize three: the Tupi province in the northeast, the Subtropicál over most of the state, and the Pampasico in the southwest. My interpretation is essentially the same as that of Cabrera and Yepes.

*Acknowledgements.*—My work in Brazil was supported by the Campanha Nacional de Aperfeiçoamento de Pessoal de Nivél Superior (CAPES) of the Brazilian Ministry of Education and Culture with a supplementary stipend from the Rockefeller Foundation. I am grateful to these two organizations for making this work possible.

For their suggestions and interest in the work, I am indebted to Werner Bokermann, Bertha Lutz, the late Karl P. Schmidt, and Paulo Vanzolini. For aid in collecting, I wish to thank A. R. Cordeiro, Eugenio Grumann, Celso Jaeger, Thales de Lema, Jorge Petersen, and F. M. Salzano. Thanks are also due Antenor L. Carvalho (Museu Nacional, Brazil), Doris Cochran (United States National Museum, USNM), and Paulo Vanzolini (Museu de Zoologia, São Paulo) for permitting me to examine specimens from the collections in their charge.

By agreement with CAPES, the majority of the specimens collected by me were equally divided between the Brazilian Museu Nacional (MN) and the Chicago Natural History Museum (CNHM). Additional specimens have been placed in the following collections: Instituto de Ciéncias Naturais (CN), Universidade do Rio Grande do Sul; Museu do Zoologia (MZ), São Paulo; Texas Technological College Zoology Collections (TT); and the Texas Natural History Collection (TNHC), University of Texas.

## *Physalaemus* Fitzinger

*Physalaemus* Fitzinger, 1826, Neue Classif. Reptilien, pp. 39, 65.

*Paludicola* Wagler, 1830, Natur. Syst. Amph., p. 206.

I have followed without exception the characteristics of the genus as given by Parker. A complete synonymy of the genus and its species may be found in Cochran (1955) and/or Parker (1927).

*Physalaemus biligonigerus* (Cope)

*Liuperus biligonigerus* Cope, 1860, Proc. Acad. Nat. Sci. Philadelphia, 12:517—Buenos Aires, Argentina.

*Paludicola biligonigerus* Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 234.

*Physalaemus biligonigerus* Parker, 1927, Ann. Mag. Nat. Hist., (9), *20:* 448.

*Physalaemus cuvieri* (part) Parker, *ibid.*, p. 461; Cochran, 1955, Bull. U. S. Nat. Mus., No. 206, p. 342.

*Descriptive notes.*—Differs from all other species in Rio Grande do Sul and almost all species of *Physalaemus* in the presence of vomerine teeth; vomerine teeth small, between internal nares; habitus bufonid- or ranid-like; sternal style strongly bifurcate; metatarsal tubercles small and conical; inner metatarsal tubercle closer to outer one than to tarsal tubercle in 92 per cent of specimens, the three tubercles equidistant in remainder; dorsal skin pustular but smoother than in *P. fuscomaculatus*; ventral skin faintly granular, with a large disk between fore and hind limbs.

Dorsal ground color pale yellowish green to light gray in life; some individuals, as in *P. gracilis*, with a brown interocular spot and many brown spots posteriorly; others as in *P. fuscomaculatus*, with brown dorsolateral stripes and a tan mid-dorsal stripe; all with a brown mid-dorsal Ω-shaped marking, the mark interrupted when mid-dorsal stripe is present; a dark stripe from rostrum diagonally from eye to venter just before the inguinal region; no lumbar ocellus; a coxal spot present in two-thirds of frogs seen; brown crossbars on arms and legs; venter dirty white, with brown flecks on anterior half; chin and modified gular skin of males heavily stippled with dark grey.

Adults from Rio Grande do Sul have a mean length of 28.6 mm., with an observed maximum of 32.2 mm.

*Call and habitat.*—The call of *P. biligonigerus* is a definite bark, "ow-oh, ow-oh . . .," somewhat reminiscent of that of *Eleutherodactylus latrans* in the United States. The frog usually calls from a clump of grass or other vegetation near the water's edge, but a few were collected as they called from open muddy areas. Some specimens were collected in forests, but most were found in grassland habitats. This frog breeds in both temporary and permanent waters on any warm, humid night from October to March.

*Remarks.*—Parker (1927) tentatively included *P. biligonigerus* in his key on the basis of Cope's inference that the type specimens had vomerine teeth. Parker, however, did not believe that any member of the genus *Physalaemus* possessed vomerine teeth, and he was of the opinion that the name "*biligonigerus*" should be a synonym of *cuvieri*. Cochran (1955) has shown that weak vomerine teeth are present in *P. cuvieri*, and this finding would seemingly favor Parker's opinion that the two names are applicable to the same species. Actually, both Parker and Cochran inadvertently lumped two species in their use of the name "*cuvieri*". One species is a large form (average length about 40 mm.) with a call described by Vanzolini (*in conversation*) as "a low, rumbling croak." The other species is a smaller form (average length less than 30 mm.) with the call described above as a definite bark. The large species ranges through eastern South America south to about 25° latitude. The smaller species occurs with the larger species throughout the latter's range and extends on south into Argentina. Size and call appear to be the only distinguishing features of the two species. The comprehensive description of "*cuvieri*" given by Cochran applies, for the most part, equally well to either species. There is a strong indication of a difference in digit length among the specimens of the two species examined by me. Most of my specimens of the smaller species are from temperate Brazil, and these have proportionately longer digits than do the specimens of the larger species from northern Brazil. This difference may be a genetic characteristic, but it may be a thermal developmental response in which the temperate-zone individuals have produced longer extremities in order to utilize environmental heat more efficiently (the opposite of Allen's Rule for homoiothermic animals).

The name *Physalaemus cuvieri*, which was resurrected by Parker, is a *nomen nudum* that could apply to either species and has been applied to both. The next available name is Cope's *Liuperus biligonigerus*. The type locality of *biligonigerus* is Buenos Aires, Argentina, and the name is thus applicable

to the smaller species but not to the larger. In the absence of a definite means of determining whether the name *cuvieri* applies to the smaller or to the larger species, I propose that the name *biligonigerus* be adopted for the smaller species. If the generic name, *Physalaemus,* is to be used, then the species name, *cuvieri,* must be retained, and I propose that it be applied to the larger species. Thus, the large species becomes, more or less by default, the type species of the genus.

*Localities.*—Specimens of *Physalaemus biligonigerus* were examined from the following localities: *Bolivia:* Santa Cruz, Buenavista (USNM). *Brazil*: Amazonas, Manáus (MZ); Bahia, no specific locality (MZ); Ceará, Munhaca (MZ); D. F., Rio de Janeiro (USNM); Espírito Santo, no spec. loc. (MN); Goiás, no. spec. loc. (NM, USNM); Miranda (MZ, USNM), no spec. loc. (MN); Minas Gerais, no spec. loc. (MN); Maranhão, no spec. loc. (MN); Matto Grosso, Barro do Tapirape (MN); Pará, Belém (MZ); Ilha de Marajó (MN); no spec. loc. (MN); Paraná, Baraqui (USNM), Curitiba (MZ); Pernambuco, no spec. loc. (MN); Rio Grande do Sul, Ana Rech (CNHM), Itapeva (CN), 2 km. SE. of Osório (MN), 10 km. SE. of Osório (CNHM, MN), Pôrto Alegre (NM, MZ), 39 km. W. of Rio Pardo (CN, CNHM, MN, TNHC, TT); Santa Catarina, no spec. loc. (MN); São Paulo, Cachoeira de Emas (MZ), Ipiranga (MZ), Ribeirão Pires (USNM), São Paulo (MN, MZ, USNM), Terceíra Repressa (USNM).

*Physalaemus fuscomaculatus* (Steindachner)

*Eupemphix fuscomaculatus* Steindachner, 1864, Verh. Ges. Wien, 14:272—Caiçara near São Luiz de Cáceres, Matto Grosso, Brazil.

*Paludicola fuscomaculatus* Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 233; Miranda-Ribeiro, 1926, Arch. Mus. Nac. Rio de Janeiro, 27:159, 221.

*Physalaemus fuscomaculatus* Parker, 1927, Ann. Mag. Nat. Hist., (9), 20:459 Cochran, 1955, Bull. U. S. Nat. Mus., No. 206, p. 345.

*Descriptive notes.*—Characterized by a large spade-shaped metatarsal tubercle; habitus bufonid-like; sternal style strongly bifurcate.

Dorsal ground color light gray in life; color pattern of darker shades of gray and brown, variable, ranges from relatively simple lines around tubercles to intricate arrangements of lines somewhat reminiscent of the lines on a topographic map; a mid-dorsal Ω-shaped marking usually present; a faint dark line merging with the lateral coloration from rostrum diagonally from eye to venter in lumbar region; lumbar ocelli precent on all Rio Grande do Sul specimens; venter immaculate white, throats of males heavily stippled with dark gray; dorsal skin very pustular, ventral skin faintly granular.

Adults from Rio Grande do Sul have a mean length of 33.0 mm., with an observed maximum of 35.7 mm. A more comprehensive description of this species has been presented recently by Cochran (1955).

*Call and habitat.*—The call of this species is a long, drawn-out, nasalized "mee-ow". It calls from the mud or grass at the water's edge and occasionally from the water. The habitat in Rio Grande do Sul is largely or entirely limited to grasslands. No specimens were collected in forests. Numerous specimens were collected from damp sand inside of mounds tossed up on sandy prairies by the gopher-like rodent, *Ctenomys.* This frog breeds in both temporary and permanent waters on any warm, humid night from October to March.

*Remarks.*—Individuals from São Paulo are considerably larger than those from Rio Grande do Sul. The average length of specimens examined from the former state is 39.5 mm., with a maximum of 43.1 mm. One specimen from Tucuman, Argentina, had a length of 44.8 mm. In addition, these larger specimens lack the lumbar ocellus that is present on the smaller specimens. The larger examples may represent a species or subspecies distinct from the smaller ones, as is the case in *P. cuvieri* and *P. biligonigerus,* or they may indicate simply that all of the specimens examined from Rio Grande do Sul were young adults.

*Localities.*—Specimens were examined from the following localities: Argentina: Tucuman (MZ). Brazil: Rio Grande do Sul, Atlántida (MN), 4 km. NE of Gravataí (CNHM, MN), 49 km. NE of Gravataí (CNHM, MN), Imbé (CNHM), 4 km. SE of Osório (CNHM), 10 km. SE of Osório (CN, CNHM, MN, TT), Pôrto Alegre (CN, CNHM, MN, MZ, TT), 50 km. SE of Pôrto Alegre at Morro do Coco (MN), 25 km. E. of Santa Maria (MN); São Paulo, São Paulo (MN, MZ), Cachoeira de Emas (MZ), Statetininga (MZ). *Paraguay*: Asunción (MN).

*Physalaemus gracilis* (Boulenger)

*Paludicola gracilis* Boulenger, 1883, Ann. Mag. Nat. Hist., (5), 11:17—Rio Grande do Sul, Brazil; Miranda-Ribeiro, 1926, Arch. Mus. Nac. Rio de Janeiro, *27*:160.

*Physalaemus gracilis* Parker, 1927, Ann. Mag. Nat. Hist., (9), 20:462, Cochran, 1955, Bull. U. S. Nat. Mus., No. 206, p. 348.

*Paludicola bischoffi* Boulenger, 1887, Ann. Mag. Nat. Hist., (5), *20*:296.

*Physalaemus bischoffi* Parker, 1927, *op. cit.*, p. 462.

*Descriptive notes.*—The most distinctive feature of this species is its coloration, especially in life. Ground color varies from grayish-brown to brown with brilliant orange flash marks in inguinal region and inner sides of lower thighs and lower legs; color pattern darker brown than ground color; an irregular (sometimes triangular) interorbital band, a mid-dorsal Ωshaped marking, and numerous irregular blotches over the entire dorsal surface; short yellow line covers the urostyle; lumbar ocelli present in about two-thirds of the specimens; coxal spots found on only one specimen; dark brown lateral stripe, bordered ventrally with white from rostrum diagonally from eye to sacral region; legs with brown cross bars.

The venter is dirty white, heavily flecked with brown from the apex of the lower jaw on to the thighs. This character is the most reliable means of distinguishing preserved specimens of *P. gracilis* and *P. biligonigerus*. The characteristic orange flash marks of the former tend to fade rapidly in preservative, and the weak vomerine teeth of the latter cannot always be located. In 58 per cent of the specimens of *gracilis* examined, the brown flecks on the chin were so arranged as to leave a narrow, white mid-line. This phenomenon was not seen in any of the specimens of *biligonigerus*. Throats of *P. gracilis* males are not heavily stippled with dark gray as in *P. biligonigerus* and *P. fuscomaculatus*.

Habitus of *P. gracilis* ranid-like; inner metatarsal tubercle closer to tarsal tubercle than to outer metatarsal in two specimens examined, all three tubercles equidistant in 12 specimens, remaining specimens with inner metatarsal tubercle closer to outer than to the tarsal tubercle; sternal style varies from single to strongly bifurcate; dorsal skin somewhat less pustular than in *P. biligonigerus*.

Adults of *P. gracilis* from Rio Grande do Sul have a mean length of 29.1 mm., with an observed maximum of 31.9 mm. A more comprehensive description of this species has been presented by Cochran (1955).

*Call and habitat:* The call of *P. gracilis* is a long, drawn-out, nasalized "mee-ow". It is indistinguishable from the call of *P. fuscomaculatus*, even when the two species are heard calling simultaneously. *P. gracilis* usually calls from vegetation near the water or projecting above the water's surface. It rarely calls from the water or from bare mud at the water's edge. The habitat of this species in Rio Grande do Sul is predominantly forest. Numerous specimens were collected from forest trails and from under logs. This frog breeds in both temporary and permanent waters in forests or on prairies near forests. Breeding occurs from October to March on any warm, humid night.

*Remarks.*—Boulenger (1887) described *P. bischoffi* from Rio Grande do Sul as distinct from all other members of the genus by having the inner metatarsal tubercle closer to the tarsal tubercle than to the outer metatarsal. Parker (1927) included this species in his list, but thought it an aberrant *P. cuvieri*. Two of my specimens of *P. gracilis* fit the main characteristic of *bischoffi* in having the inner metatarsal tubercle closest to the tarsal tubercle, and 12 specimens have all three tubercles equidistant. Only a few of my specimens of *P. biligonigerus* (*cuvieri* of Parker in this case) have all three tubercles equidistant and none has the inner metatarsal closer to the tarsal than to the outer metatarsal. For this reason and the reason that Boulenger's figure looks like a typical example of *gracilis* I consider *P. bischoffi* as a synonym of *P. gracilis*.

Another species, *P. fernandezae* of Müller (1926) may not be distinct from *P. gracilis*. Parker (1927) describes *fernandezae* as a small species with a snout 1⅔ the diameter of the eye and with a concave loreal region. It is known only from the type specimen. *P. gracilis* is the only species near the type locality of *fernandezae* that occasionally has a concave loreal; but *gracilus* is a large species, and no specimens examined have a snout of that length. The maximum snout length observed is 1⅔ times the diameter of the eye.

*Localities.*—Specimens of *Physalaemus gracilis* were examined from the following localities: Brazil: Paraná, Rio de Aréia (USNM); Rio Grande do Sul, Ana Rech (MN), 18 km. S. of Farroupilia (CNHM, MN), Niterói (CNHM, MN), 10 km. SE. of

Osório (CN, CNHM, MN), Pôrto Alegre (CNHM, MN), 50 km. SE. of Pôrto Alegre at Morro do Coco (GNHM, MN), 39 km. W. of Rio Pardo (CNHM, MN, MZTT), no specific locality (USNM); Santa Catarina, Lagôa (USNM), Nova Teutonia (USNM); São Paulo, Bonito (USNM). *Paraguay:* Sapucai (USNM). *Uruguay:* Montevido, Buceo (USNM); no specific locality (USNM).

*Physalaemus henseli* (Peters)

*Paludicola henselii* Peters, 1872, Monatsber. Akad. Wiss. Berlin, *1872*:223—Rio Grande do Sul.

*Paludicola henseli* Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 235; 1887, Ann. Mag. Nat. Hist., (5), *20*:296; Miranda-Ribeiro, 1926, Arch. Mus. Nac. Rio de Janeiro, *27*:163, 222.

*Physalaemus henselii* Parker, 1927, Ann. Mag. Nat. Hist., (9), *20*:463.

*Descriptive notes.*—Habitus ranid-like; two small, conical metatarsal tubercles and a small tarsal tubercle present; inner metatarsal tubercle closest to tarsal tubercle on one specimen and closest to outer metatarsal tubercle on ten specimens; sternal style is single in ten specimens and slightly bifurcate in one.

Dorsal ground color grayish-brown to brown in life; a light vertebral stripe present, most distinct over the urostyle; one or two irregular dark stripes present on each side of light vertebral stripe; a dark stripe usually bounded below by a white line diagonally from eye to inguinal region; area between dorsal and lateral stripes pale orange; dorsal surface of legs indistinctly cross-barred with dark brown; lumbar ocelli absent; coxal spots present in two specimens and absent in nine; venter a dirty white, densely stippled with light brown; a diffused blotch of pale orange coloration on each side of the ventral midline; modified gular region of males no darker than other parts of venter.

The average length of specimens examined from Rio Grande do Sul was 20.0 mm. and the maximum was 22.8 mm.

*Habitat.*—Three of my specimens were taken from the margin of a prairie pool at the edge of the forest. The others were all taken from under logs in forests. No calling individuals were found.

*Remarks.—Physalaemus barbouri* of Parker (1927) from La Plata, Argentina, probably is not distinct from *P. henseli*. The former is described as differing from the latter by having a slightly longer snout, by having shorter hind limbs, by lacking a white, dark-bordered line on the upper jaw, and by having shorter digits. Parker gave no means of comparing the lengths of the digits, except in relation to each other. In ten specimens of *P. henseli* examined, a white, dark-bordered line on the upper jaw was found to be distinct in four, indistinct in three, and absent in three. Parker states that the metatarsal tubercles of the adpressed hind limb of *P. barbouri* reach the eye. In 11 specimens of *P. henseli*, the tubercles reach a point just in front of the eye in two, even with the end of the snout in three, and beyond the end of the snout in six. The length of the snout of *P. barbouri* is described as being "rather longer than the diameter of the eye". In 11 specimens of *P. henseli*, the snout length varies from .75 to 1.23 times the diameter of the eye, with an average of .92.

The large variation in the length of the hind limb of *P. henseli*, as measured by the point attained by the metatarsal tubercles of the adpressed hind limb, is exceeded in other species of the genus. It might be suggested, therefore, that the variation is a result of different methods of comparison or differences produced by preservation.

*Localities.*—Eleven specimens of *Physalaemus henseli* and one skin were examined from three localities in Rio Grande do Sul, Brazil: Pôrto Alegre (USNM), 50 km. SE. of Pôrto Alegre at Morro do Coco (CNHM, MN), and 39 km. W. of Rio Pardo (CN, CNHM, MZ, TT).

***Physalaemus riograndensis*** *sp nov.*

*Holotype.*—A male, Chicago Natural History Museum, No. 82578 collected on February 26, 1955, by W. W. Milstead and J. A. Petersen from a small pond flooded by rains.

*Type locality.*—4 kilometers southeast of Osório, Rio Grande do Sul, Brazil.

*Diagnosis.*—The quadratojugal is present and continuous with the maxilla, as characteristic of the genus (Parker, 1927). This is the smallest member of the genus yet discovered, and the only small member of the genus to have a bufonid-like habitus. It is the only member of the genus in which the dorsal ground color is dark grayish-brown to black, and in which there is a broad midventral, light stripe bounded by heavy, dark-gray marblings.

*Description of holotype.*—Vomerine teeth absent; sternal style strongly bifurcate;

tongue elliptical (somewhat reminescent of a bowling pin), margin entire, free behind; rostrum rounded, not prominent; canthus rostralis prominent, rounded; loreal region concave; snout length 2.28 mm.; eye fairly prominent, 2.68 mm. in diameter; eyelid width 1.36 mm.; interorbital distance 1.70 mm.; tympanum invisible; fingers and toes short with little or no webbing; toes with a lateral fringe extending to (but not including) the last phalanx; numerous, distinct tubercles on both palms and soles; two metatarsal tubercles and one tarsal tubercle; inner metatarsal tubercle closer to outer than to tarsal tubercle; metatarsal tubercles extend to a point even with the eye when the limb is adpressed; dorsal skin very tuberculate, more so than in any other member of the genus; inguinal gland a slightly raised, flat disc, 2.66 mm. in diameter; ventral skin granular and very loose with a poorly defined ventral disc. A large subgular vocal sac opens into the buccal cavity by a longitudinal slit on each side of the tongue.

The dimensions of the type are: snout-vent length 18.6 mm.; head length 6.08 mm.; head width 5.84 mm.; upper arm 2.82 mm.; lower arm 3.62 mm.; hand length 3.82 mm.; longest finger 2.76 mm.; thigh 7.60 mm.; lower leg 7.92 mm.; tarsus 4.68 mm.; foot 6.92 mm.; and longest toe 4.56 mm.

Dorsal ground color a dark grayish-brown in life; a slightly darker indistinct Ω-shaped figure mid-dorsally and a figure W on and between the eyelids; a faint, mid-dorsal light stripe from between eyes to about even with tympanum; another, slightly broader, light stripe covers the urostyle; center of Ω-shaped figure marked by an indistinct light blotch; no indication of lumbar ocelli or coxal spots; limbs indistinctly crossbarred with dark gray; venter a dirty white heavily marbled with gray and appears more dark than light, gray marblings are so arranged as to leave a light stripe from snout to vent; stripe increases slightly in width posteriorly.

*Paratypes.*—Twenty-two specimens are designated as paratypes of *Physalaemus riograndensis*: CNHM 82579–82583, MN 2578–2583, and MZ 1052 (field number), from the type locality and collected with the holotype: CNHM 82584 and MN 2577 from 25 kilometers east of Santa Maria, R. G. S.; and CN 326 (field number) and 340 (field number), CNHM 82585–82586, MN 2576, MZ 315 (field number), and TNHC 21004 and 23312 from 39 kilometers west of Rio Pardo, R. G. S. Two additional specimens that are not designated as paratypes were examined. These are the two skin preparations shown in Fig. 1.

Variation in the paratypes and additional specimens is slight. Most have the coloration of the holotype, but a few have a lighter ground color with more distinct markings, and a few others have a darker ground color with less distinct markings. Those with more distinct markings have a suggestion of coxal spots. Those with less distinct markings either lack the anterior, mid-dorsal, light stripe or have it replaced with one to three light blotches Fig. 1. Variation in the ventral coloration is much the same as in the dorsal coloration. Most of the paratypes agree with the holotype, but some have more and some fewer dark marblings.

In the holotype, the snout length is 85% of the eye diameter. In the paratypes, the percentage varies from 84.7 to 106.4, with a mean of 94.4%. The two metatarsal tubercles and the tarsal tubercle of one of the paratypes (MZ 315; field number) are equidistant from each other. All other specimens agree with the holotype in having the metatarsal tubercles located closer to each other than either is to the tarsal tubercle. When the hind limbs of the paratypes are adpressed, the metatarsal tubercles extend to a point between the tympanum and the eye in 15%, even with the eye in 40%, and between the eye and the nostril in 45%. All of the paratypes are adults collected while calling or in amplexus. The snout-vent lengths of these specimens vary from 16.1 to 20.1 mm. with a mean of 17.7 mm.

*Call and habitat.*—The call of *P. riograndensis* is a long, drawn-out, nasalized "mee-ow". It is indistinguishable from the calls of *P. fuscomaculatus* and *P. gracilis*. The call of *P. riograndensis* is given from the water. In rest between calls, the individual floats on the surface of the water. It is held bouyant by its torso. The sides are expanded until the width fully equals the snout-vent length. The abdomen is swollen downward to about half the length. The head is inclined upwards and the legs are spread. Thus, an observer gets the impression of a ball cut in half with legs and a head projecting from the flat, upper surface. When the call is given, the great quantity of air held in the sides and abdomen is shifted forward to the large vocal sac, causing the torso to sink. The call is given while the frog is in

an almost vertical position suspended in the water by the vocal sac. Following the call, the air is again shifted and the frog returns to a horizontal position.

All of the specimens were collected in January and February from flooded prairies, or from prairie pools or streams, and always after heavy rains. Of the 25 specimens of *P. riograndensis*, 14 were collected on nights following an all-day rain, and 13 on nights following a two-day rain. None was collected after rains of short duration or on clear nights.

*Comparisons.*—The call of *riograndensis* indicates affinity with *fuscomaculatus, gracilis,* or both. The dark marblings of the venter and the mid-ventral, light stripe present a ventral color pattern closer to that of *gracilis* than to any other species in the genus. On the other hand, the bufo-like body and warty skin of *riograndensis* are similar to *fuscomaculatus,* and *fuscomaculatus* is the only other species in southern Brazil that may (although rarely) call from the surface of the water in the manner of *riograndensis.* If the call is considered to be the result of parallelism, then the small size of *riograndensis* may be indicative of relationship with *henseli* or some other small species.

## Summary

The genus *Physalaemus* is represented in southern Brazil by *P. biligonigerus, P. fuscomaculatus, P. gracilis, P. henseli,* and a new species named *P. riograndensis* in honor of the southernmost state in Brazil, Rio Grande do Sul. *Physalaemus biligonigerus* and *P. cuvieri* have been confused by previous workers; the range of *P. biligonigerus* is much broader than formerly thought. The name *P. fuscomaculatus* may actually include two species or two geographic races. *P. bischoffi,* (Boulenger, 1887) and *P. gracilis* are considered to be conspecific. *Physalaemus fernandezae* (Muller, 1926) may also be conspecific with *P. gracilis,* and *P. barbouri* (Parker, 1927) may be conspecific with *P. henseli.*

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Department of Biology, The University of Kansas City, Missouri.

# On *Neoscaphiopus* and other Pliocene Pelobatid Frogs

J. A. Tihen

THE genus *Neoscaphiopus* was proposed by Taylor (1942) for the species *N. noblei,* described from the Upper Pliocene Rexroad formation of Meade County, Kansas. The species was represented only by the holotype, consisting of two rather well developed vertebrae and the coccyx, all fused. For a second specimen from this deposit, an essentially "normal" spadefoot sacrococcyx, he proposed the name *Scaphiopus diversus.* At that time no other fossil specimens of spadefoot toads were known from the Upper Pliocene.

Several questions have arisen concerning both the proper morphological interpretation of the type specimen of *N. noblei* and the proper taxonomic interpretation of that morphological condition. A few more specimens are now available from the Rexroad, another fossil form has been described from the Lower Pliocene (Zweifel, 1956), and we now have more information concerning the

osteology of Recent spadefoot toads than was formerly available. Although these additional items of information are still inadequate to provide conclusive answers to the problems involved, they do provide a base for certain inferences.

An attempt to evaluate the taxonomic significance of the morphological characteristics of any specimen implies a knowledge of exactly what these characteristics are; in this instance the implication is not entirely accurate. Taylor assumed that these two vertebrae were the normal sacral (9th) and the presacral (8th). Ritland (1955) feels that the two vertebrae are the sacral (9th) and a postsacral (10th). If assumptions to be made later are correct, this is not actually a critical point; it nevertheless merits discussion.

Adolphi (1895) described variations in the vertebral column and spinal nerves of 65 specimens of *Pelobates fuscus*; in seven of these the sacrum was formed in part from a 10th, i.e. postsacral, vertebra. In one of the seven this postsacral vertebra bore nearly all of the sacral expansion; in none of the 65 was the 8th, or presacral, vertebra fused with the 9th. In *Spea* (whether this group be considered a genus or subgenus) discernible diapophyses on a postsacral vertebra are normally present. The extent of their development is extremely variable; in no specimen that I have seen do the postsacral diapophyses contribute the major part of the sacral expansion, but the extent of observed variation is such as to indicate that this might well occur in rare instances. These facts were taken by Ritland as proof that the type specimen of *Neoscaphiopus* consisted of a sacral and postsacral vertebra fused with the coccyx, and that the specimen must represent only an extreme variant of *Spea*.

On the other hand, fusion of the sacral and presacral vertebra is known to occur in *Spea*, even though rarely (*fide* Duellman, as quoted by Zweifel, 1956). In the Lower Pliocene *Scaphiopus* (*Neoscaphiopus*?) *alexanderi* the entire vertebral column is present, and in that specimen the 8th and 9th vertebrae are fused to form the sacral portion of the sacrococcyx. This combined element has an appearance essentially identical with that of the type specimen of *noblei*. These facts, along with the fact that no Recent specimen of *Spea* has actually been reported in which the postsacral vertebra contributes most of the sacral expansion, may indicate that the type of *noblei* is composed of an 8th and 9th vertebra fused with each other and with the coccyx.

Three more pelobatid sacrococcyges (part of UMMVP 38758) are now available from the type horizon and type locality of *noblei* and a fourth (UMMVP 30583) from the nearby and contemporaneous Fox Canyon deposits. With the exception of one of the specimens under No. 38578, all of these are essentially "normal" in appearance. The exceptional specimen involves two distinct vertebrae, with a strongly elevated ridge on the dorsal surface between the two (Fig. 1) just as in the type specimen of *noblei*. In Recent *Spea* that I have seen, such a ridge is at most only moderately prominent. But this specimen differs sharply from the type specimens of both *alexanderi* and *noblei* in other important respects. In both of those, the more posterior of the two vertebrae involved is the one whose diapophyses provide most of the sacral expansion, and in each the two nerve foramina present are essentially equal in size. In the additional specimen from the Rexroad, although only the bases of the diapophyses are present, the more anterior vertebra provides the major portion of the sacral expansion; the posterior nerve foramen, though larger than is usual for the postsacral foramen in *Spea*, is nevertheless smaller than the more anterior one, and not outside of the observed range of variation in *Spea* (Fig. 2).

Thus, of the three known sacrococcyges referable to *Neoscaphiopus* one, the type of *alexanderi*, definitely involves a sacral and a presacral vertebra. In a second, the type of *noblei*, the two vertebrae cannot be definitely identified, but the relative extent of the diapophyses and size of the nerve foramina favor a similar interpretation. In the third, the additional Rexroad specimen, identification is similarly indefinite but these same considerations favor interpretation as a sacral and an exceptionally well developed postsacral.

Whatever the identity of the vertebrae involved, and whether or not they are the same in all three instances, the frequency with which two vertebrae participate prominently in formation of the sacrum is greater in the fossil specimens than in Recent. This was pointed out by Zweifel (ibid.) and is corroborated by the recovery of additional fossils and by examination of a greater number of Recent specimens. I have observed no instances of sacral-presacral fusion in approxi-

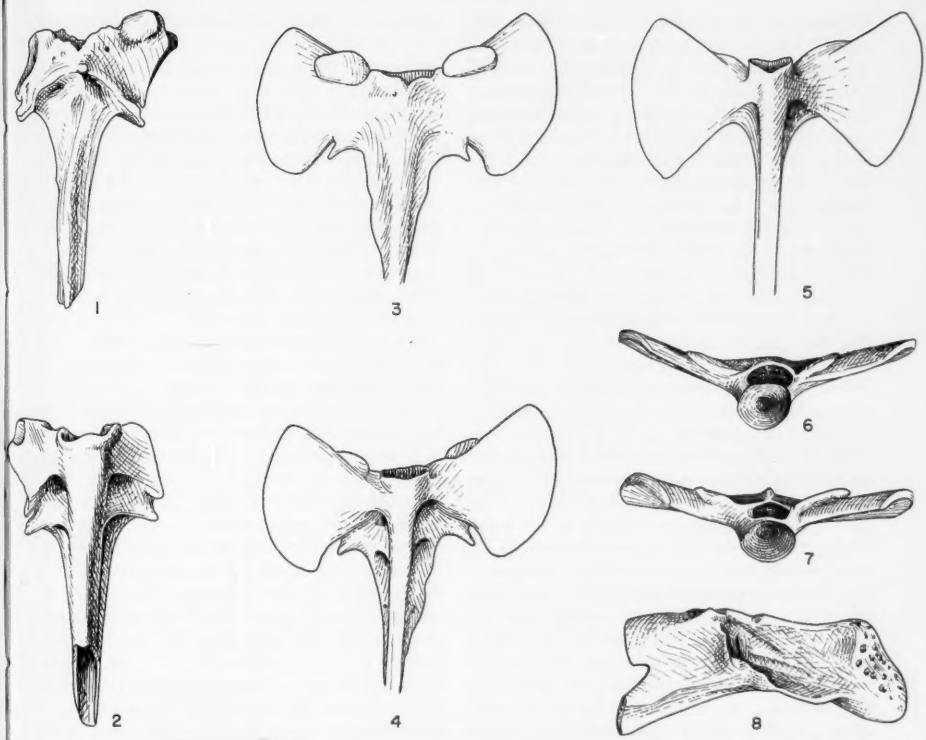


FIG. 1.—"Abnormal" sacrococcyx from the Rexroad, UMMVP 38758, dorsal aspect. 2.—Same, ventral aspect. 3.—Sacrococcyx of *Spea bombifrons*, dorsal aspect. 4.—Same, ventral aspect. 5.—Sacrococcyx of *Scaphiopus holbrooki*, ventral aspect. 6.—Anterior end of sacrococcyx of *Spea bombifrons*. 7.—Anterior end of sacrococcyx of *Spea hammondi multiplicata*. 8.—Ethmoid from the Rexroad, UMMVP 38758. All figures approximately 4½ times natural size.

mately fifty Recent *Spea*, nor were any observed by Zweifel; the only recorded instance is the observation by Duellman, mentioned previously. The postsacral diapophyses take a definite, but minor, part in the iliac articulation in only one of these specimens. In two specimens I have noted a transverse ridge on the dorsal surface similar to that in the fossil specimens, but less elevated. In contrast, three of the ten known spadefoot sacrococcyges from the Pliocene exhibit a prominent involvement of two vertebrae and a strong transverse ridge.

Although these extreme variants occur only rarely in Recent *Spea*, extensive variation in the exact extent of the postsacral diapophyses, in the amount and shape of webbing between the sacral diapophyses and the shaft of the coccyx, and in the size and position of the postsacral nerve foramen or foramina does occur. In three of fifteen *S. hammondi* that I have seen, and in one of four figured by Zweifel, the webbing is limited in extent and regular in outline, comparable to the usual condition in *Scaphiopus* proper. In all other specimens seen this webbing is more extensive and irregular in outline; the figures provided by Zweifel portray examples of this extensive variation.

In Recent members of *Scaphiopus*, though some variation in the form of the sacrococcyx does occur, its shape is relatively constant. The webbing between the sacral diapophyses and coccygeal shaft is limited in extent and regular in outline; this distinction between *Scaphiopus* and *Spea* has also been noted by Chrapliwy (1956). Of nine specimens of *S. holbrooki* and seven of *S. hurteri* at hand, none differ appreciably from the specimen shown in Figure 5. The webbing seems

slightly more extensive in *couchi* (six specimens), and in one specimen of that species is slightly irregular in outline. A postsacral nerve foramen is present in both *Scaphiopus* and *Spea*; in the former it is consistently very small, while in the latter it varies from very small to fully two-thirds of the size of the sacral nerve foramen, its size roughly correlated with the extent of development of the postsacral diapophyses. I have seen no *Scaphiopus* in which the sacral and presacral vertebrae are fused, or in which there is a transverse ridge on the dorsal surface.

Thus *Spea* differs from *Scaphiopus* proper not only in the typical form of the sacrococcyx but also in the extent and frequency of variation from that typical form. As noted above, considerable variation also exists in *Pelobates*. *Megophrys* is by no means constant in vertebral characteristics, though the known variation does not necessarily involve the sacrococcygeal portion of the column in most instances. Extreme variants in the form of the sacrococcyx occur more frequently in the Pliocene spadefoot toads than in Recent populations. It seems legitimate to postulate that early pelobatids, and specifically the early *Scaphiopus-Spea* progenitors, exhibited considerable vertebral variation. In Recent representatives this variation has been reduced—more markedly reduced in *Scaphiopus* proper than in *Spea*. We could then reconcile the frequency of occurrence of "abnormalities" in the fossil specimens with assignment of these specimens to *Spea*. The differences between the Pliocene spadefoots and Recent *Spea* would be considered lineal temporal differences rather than divergence between collateral and formerly contemporaneous groups. The fossil specimens would not then be thought of as "slightly abnormal" specimens of *Spea*, but would fall well within the range of a somewhat broadened normal variation.

Support of such a postulate is provided by the Rexroad specimens. In all six of the known sacrococcyges the cotyle for articulation with the next anterior vertebra is round, or nearly so. Among Recent American pelobatids this is consistently true only in *S. bombifrons*; in all others this cotyle is ovoid, with a vertical diameter rarely exceeding 75% or 80% of the horizontal diameter (Figs. 6, 7). This is true both for the usual sacral articulation, i.e., between the 8th and 9th vertebrae, and for the articulation between the 7th and 8th vertebrae, so the possible involvement of a presacral vertebra in the sacrococcyx does not invalidate the comparison. In addition to the sacrococcyges, three pelobatid ethmoids (also under UMMVP No. 38758) have now been recovered from the Rexroad. In two of these the anterior end is present and exhibits a conspicuous, ventrally deflected proboscis-like process (Fig. 8). Such a process is, like the round sacral cotyle, characteristic of and limited to *bombifrons* among Recent forms, as has been noted by Taylor (1941). Although this feature is not determinable on the third fossil ethmoid, that specimen is otherwise in full agreement with the other two.

The evidence is strong that some form closely related to *bombifrons* is represented in the Rexroad collection. The only evidence that a second form not so related might also be present is the extensive development of two vertebrae in the "abnormal" sacrococcyges. Even in these the cotylar shape suggests affinity with *bombifrons*, and the two specimens are not consistent with each other in the relative extent of the two vertebrae involved. The most likely interpretation is that (a) all of the specimens represent a single form, (b) this form is closely related, possibly directly ancestral, to *Spea bombifrons*, and (c) this form differs from *bombifrons* in having a more variable sacrococcyx with a more frequent involvement of two well-defined vertebrae in that structure. Other differences cannot be determined from the available material.

In the belief that this is actually the case, I propose to consider *Neoscaphiopus* a synonym of *Spea*, and *Neoscaphiopus noblei* Taylor a synonym of *Scaphiopus diversus* Taylor. The latter species is tentatively referred to *Spea*, and has close affinities with, and perhaps is directly ancestral to, *Spea bombifrons*.

Under such an arrangement, and such a broadened concept of the extent of variation in *Spea*, the species *alexanderi* Zweifel should also be referred to *Spea*, as suggested by Chrapliwy (op. cit.). The species *studeri* Taylor from the Middle Pliocene of Logan County, Kansas, is definitely referable to *Spea* as evidenced by the possession of a frontoparietal fontanelle. It differs from *diversus* and *bombifrons* in having an oval sacral cotyle and in lacking the distinctive structure of the ethmoid exhibited by those forms.

The species *pliobatrachus* Taylor and *antiquus* Taylor are each based on a sacrococcyx; both are from the Middle Pliocene

Edson Beds of Sherman County, Kansas. These specimens appears referable to *Spea* on the basis of the amount and disposition of webbing between the sacral diapophyses and shaft of the coccyx and extent of development of postsacral diapophyses. Although differing from each other in details, they differ to no greater extent nor in any different manner than do individuals within any of the Recent species of *Spea*. The two specimens probably are conspecific, and I tentatively consider *antiquus* to be a synonym of *pliobatrachus*. As in *studeri*, the sacral cotyle is ovoid; it differs from *studeri* in having prominent radioulnar and preaxial humeral crests, assuming that limb bones from the Edson Beds can be associated with the sacrococcyges. In this respect *pliobatrachus* resembles *hammondi* and others among the Recent forms; such crests are lacking or poorly developed in most *bombifrons*. No forelimb elements have been recovered from the Rexroad, so the condition in *diversus* is not known.

If *diversus* does indeed bear a linear relationship to *bombifrons*, and especially if the major point of distinction between the two is the extent of variability in the form of the sacrococcyx, then any temporal series of Pleistocene specimens must be more or less arbitrarily assigned to one species or the other. No such temporal series of specimens has been recovered; all Pleistocene specimens known from this general area are from deposits presumably of Sangamon age. One sacrococcyx and an ilium from the Jinglebob fauna have been previously reported (Tihen, 1954) and referred tentatively to *bombifrons*. A number of specimens, including four sacrococcyges and two ethmoids, are known from the Cragin Quarry fauna of Meade County, Kansas, also presumably of Sangamon age (*vide* Etheridge, 1958). In one of these specimens the postsacral vertebra is exceptionally well developed; it approaches the "*Neoscaphiopus*" condition, but is still within the observed range of variation in *bombifrons*. All other Cragin Quarry specimens are fully consistent with reference to *bombifrons*, and all are tentatively so referred.

Excluding specimens of *Scaphiopus holbrooki* from the Pleistocene of Florida, the Miocene occurrence of the same or a similar form from that state (Auffenberg, 1956) and the Oligocene appearance of *Eopelobates* in South Dakota (Zweifel, 1956), I consider all fossil pelobatids so far reported from the United States to be referable to *Spea*. Known occurrences are as follows:

*Spea alexanderi* Zweifel: Lower Pliocene of Nevada.

*Spea diversus* Taylor: Upper Pliocene of Kansas (*Neoscaphiopus noblei* Taylor is a synonym of this species).

*Spea pliobatrachus* Taylor: Middle Pliocene of Kansas (*Scaphiopus antiquus* Taylor is a synonym of this species).

*Spea studeri* Taylor: Middle Pliocene of Kansas.

*Spea bombifrons* Cope, an extant form, has been tentatively identified from the Sangamon Cragin Quarry and Jinglebob faunas of Meade County, Kansas.

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DEPARTMENT OF ZOOLOGY, UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS.

# Growth and Cyclic Behavior in the West African Lizard, *Agama agama africana*

PAUL M. DANIEL

THE general subject of animal breeding cycles and the environmental factors that influence them is well studied in birds and mammals (Rowan, 1937; Baker, 1939; Marshall, 1942). Amphibians, fishes, and reptiles have been studied less. It is generally recognized that light is an important factor affecting reproductive activity in the temperate zones. The viviparous Desert Night Lizard *Xantusia vigilis,* investigated by Miller (1948a, 1948b, 1951) and Bartholomew (1955), has a testicular cycle very closely correlated with day length and an ovarian cycle not so affected. Clausen and Poris (1937) have demonstrated the effect of light experimentally with *Anolis carolinensis,* while Hamlett (1952) has demonstrated that females of this species produce ova every two weeks and males are potentially reproductive all summer. Fox (1958) and Dessauer (1955) have shown that spermatogenesis of *Anolis carolinensis* in Louisiana is initiated in a period of decreasing day length in November and continues throughout the period of increasing day length until August. The factors involved in zones close to the equator where photoperiod is relatively constant are less understood. Baker (1947), in studying the skinks *Emoia cyanura* and *E. werneri* in the New Hebrides Islands (15°15′ S), found that breeding was not confined to a single season but occurred throughout the year with certain phases of the reproductive cycle more prevalent in some seasons. The factors responsible for breeding are not known. Baker states that rainfall and/or intensity of insulation may be responsible for tropical breeding seasons. Usually in regions with wet and dry seasons breeding occurs after the onset of the rains.

## THE STUDY AREA

The writer investigated the life history of the lizard *Agama agama africana* (Hallowell) on and near the campus of Cuttington College, Suacoco, Liberia (7°5′ N 9°3′W) (Daniel, 1954). The chief vegetation of the study area was low bush which is characteristically abandoned farm land covered with thick vegetation with dominant stems from ten to fifty feet high but no true canopy. Some areas of true rainforest also remain in this section of Liberia. This lizard was encountered most often, however, in regions cleared for farms, villages, lawns, roads, trails and buildings. This species has also been reported from this type of habitat in other parts of West Africa (Cansdale, 1951; Hallowell, 1845; Romer, 1953).

*Rainfall and temperature.*—Rainfall and maximum and minimum temperatures were recorded daily. Rainfall data are included in Table I. The average annual rainfall is about 80 inches with two maxima, one in July and one in September. There is a dry season from December well into March. Maximum temperature of 101° F. was recorded in September, 1952, and November, 1952. The minimum temperature of 62° F. was recorded at night in December, 1952. The greatest daily variation was 32° F. (94° to 62°) in December, 1952. The usual variation was approximately 15° F. No significant temperature difference in the seasons was noted. The relative humidity, taken with a sling psychometer once a day at sunset, varied from 56 per cent and 95 per cent, with percentages in the eighties most frequent. The lowest humidity was recorded twice during the January–February 1953 period. The humidity averaged about 10 per cent

higher during the rainy season than in the dry season.

### Growth and Development

*Ova.*—Romer (1953) reported three ova of *Agama agama* from Port Harcourt, Nigeria, deposited June 15 and hatched September 9. Eggs brought into our laboratory June 11, 1952, were in the process of hatching. They had been deposited in loose soil cleared for planting cocoa seedlings. There were four elliptical eggs and two newly hatched lizards, and it was reported that three other eggs had been destroyed. Six eggs brought in on June 30, 1952, hatched July 1 and 2. A third set of six eggs collected on the surface of lateritic soil in a garden were brought in July 11, 1952. The eggs were all elliptical in shape and ranged from 19 to 26 mm. in length and from 2.9 to 3.8 gms. in weight.

*Hatchlings and juveniles.*—Two groups of hatchlings ranged from 30 to 34 mm. snout tip to anus, and from 72 to 84 mm. total length. This compares with Romer's (ibid.) measurements of 35 to 37 mm. and 72 to 76 mm. on hatchlings. A total of 208 lizards was measured, dissected, and their sexual development recorded. Seventeen of these, captured between August 19, 1952, and February 7, 1953, had snout to anus measurements of 50 to 59 mm. Preanal pores, not visible in hatchlings, were visible at this stage of development. Measurements of the longer testis in each of the six males were from 1.9 to 4.1 mm., the longest belonging to an individual collected on February 7.

The larger of the ovaries in the females ranged from 2.0 to 3.0 mm. The total lengths of these juvenile lizards with unbroken tails ranged from 130 to 155 mm.

*Subadults and adults.*—Seventeen lizards in the size range 60–69 mm. (snout to anus) were from 133 to 177 mm. in total length (in those with unbroken tails). The larger testis in each male ranged from 2.3 to 5.9 mm. In females ovaries ranged up to 5.2 mm. These subadult lizards were captured between July and February.

The fifteen males and sixteen females between 70 and 79 mm. (total lengths 140 to 202 mm. in those with unbroken tails) were captured in all months except March and May. In this size range the lizards reach adulthood but do not cease to grow. In these males the larger testis varied from 1.9 to 7.3 mm. in length. All of the females had developing follicles, one had follicles up to 10 mm.; another with a snout to anus measurement of 75 mm. captured in December, had five well developed oviducal eggs. Twenty males, 80 to 89 mm. snout to anus, eighteen 90 to 99 mm., and twenty-eight 100 mm. and over were recorded. The maximum male snout to anus length was 118 mm. and the greatest total length was 275 mm. Forty females had snout to anus measurements of 80 to 89 mm. and twenty-five were from 90 to 101 mm. Maximum total length for females was 240 mm.

Table I

Rainfall (in inches) at Cuttington College, Suacoco, Liberia. August, 1952, to September, 1953

| Month | 1952 | 1953 |
|---|---|---|
| January | | 1.45 |
| February | | 2.83 |
| March | | 3.36 |
| April | | 9.13 |
| May | | 8.22 |
| June | | 7.06 |
| July | | 12.97 |
| August | 7.71 | 8.69 |
| September | 16.67 | 10.17 |
| October | 8.54 | |
| November | 3.77 | |
| December | 0.23 | |
| Average annual Cuttington rainfall | | 79.18 |

### Seasonal Cycles in Gonads

*Males.*—The males of *Agama* were divided into two size groups, those 90 to 99 mm. and those 100 mm. or more. Within each size group the lizards were placed in seasonal categories: those of the late rainy season (August, September, October, and November) of 1952, those of the dry season (December 1, 1952, to April 1, 1953), and those of the early rainy season (April, May, and June). A few individuals were anesthetized and examined for motile sperm in the vasa deferentia. In addition to information in Table II, motile sperm were found in a specimen of 111 mm. having testes of 12 mm., from the early rainy season of 1952. The average size of testes for each of these groups is indicated in Table 2. In both size groups the testes had longer average lengths in the dry season than in the late rainy season and still longer lengths for the early rainy season. Size increase may

TABLE II

AVERAGE TESTIS SIZES OF SEASONAL GROUPS OF MALE *Agama agama africana*. AUGUST, 1952, TO JULY, 1953

| | Lizards 90 mm. to 99 mm. | | | Lizards over 100 mm. | | |
|---|---|---|---|---|---|---|
| | Late Rainy Season | Dry Season | Early Rainy Season | Late Rainy Season | Dry Season | Early Rainy Season |
| Number | 8 | 9 | 1 | 5 | 17 | 6 |
| Average Snout to Anus Size mm. | 94.6 | 94.2 | 95 | 107.4 | 107 | 107 |
| Average Testis Size mm. | 5.94 | 6.5 | 6.95 | 6.63 | 7.41 | 7.93 |
| Size Range of Testes mm. | 4.9–9.0 | 5.4–9.3 | | 5.0–8.0 | 6.1–9.0 | 6.4–9.8 |
| Motile Sperm | found in 3 out of 3 | — | — | found in 1 out of 2 | found in 2 out of 2 | |

TABLE III

SEASONAL DISTRIBUTION OF FEMALE *Agama agama africana* (80 MM. AND OVER) WITH RESPECT TO REPRODUCTIVE STAGES

| | Late Rainy Season | Dry Season | Early Rainy Season |
|---|---|---|---|
| Total Number | 7 | 43 | 13 |
| Non-Reproductive | | | |
| Number | 4 | 0 | 0 |
| Percent | 57 | 0 | 0 |
| Fecund | | | |
| Number | 1 | 27 | 6 |
| Percent | 14 | 63 | 46 |
| Ovigerous | | | |
| Number | 2 | 16 | 7 |
| Percent | 29 | 37 | 54 |

indicate an increase in the production of sperm. Sperm production probably occurs throughout the year, increasing in the dry season and reaching a peak in the rains.

*Females.*—Sixty-three adult females (80 mm. or more, snout to anus) were found between August, 1952, and June, 1953. Oviducal eggs, indicating ovigerous lizards, varied in number from three to nine, were elliptical in shape, and were 12.0 to 20.5 mm. in length. Females with developing follicles larger than 3.5 mm. were considered fecund. These follicles numbered from five to fourteen, were spherical, and were as much as 11.9 mm. in diameter. Both ovigerous and fecund individuals were present in all seasons (Table III); hence there is probably year round breeding with no sharply defined breeding season. However, the percentage of ovigerous individuals was greatest in the early rainy season, the same period in which males showed an increase in size of testes, indicating maximum breeding activity at this time.

## DISCUSSION AND SUMMARY

Six to nine eggs may be deposited in June, July or possibly earlier. Probably hatchlings increase by about one-third in snout to anus length in three to six months. Lizards approaching 60 mm. are about twice the size of hatchlings and probably one year old. Sexual maturity is attained in lizards of both sexes at about 80 mm. in length; these lizards are probably in their second year of life.

This *Agama*, like the New Hebrides skinks (Baker, 1947), shows reproductive activity at various times in the year. The increase in testis size and percentage of ovigerous females indicates the late dry and early rainy season as the period of maximum breeding activity.

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PHYSIOLOGY DEPARTMENT, MIAMI UNIVERSITY, OXFORD, OHIO.

# Variation, Distribution, and Ecology of the Mexican Teiid Lizard *Cnemidophorus calidipes*

WILLIAM E. DUELLMAN

IN 1955 I described *Cnemidophorus calidipes* on the basis of 18 specimens from Michoacán, México. Field work in 1956 and 1958 greatly increased the number of specimens and provided data concerning variation, distribution, and ecology of these lizards. Aside from observations made in the months of June and July, 1955, field studies were carried out in the months of April, May, July, and August, 1956, and in June and July, 1958. The examination of specimens of *Cnemidophorus "sacki"* in certain museum collections revealed the presence of additional specimens of *calidipes*. The purpose of this report is to bring up to date the accumulated knowledge on various aspects of the biology of the species.

Abbreviations for museum specimens are: Chicago Natural History Museum (CNHM), University of Kansas, Museum of Natural History (KU), University of Michigan Museum of Zoology (UMMZ).

## VARIATION

At present 136 specimens of *Cnemidophorus calidipes* are available for variational studies; 90 are males, 44 are females, and two are hatchlings. The following description of variation is intended to supplement that given by Duellman (1955).

*Scutellation.*—Important characters of scutellation in the *Cnemidophorus sacki* complex are the numbers of femoral pores, numbers of dorsal granules (see Zweifel, 1959), and the extent of the supraorbital semicircle series. The dorsal granules are relatively large and vary in number from 66 to 86 around the midbody—in 90 males from 66 to 86 ($74.8 \pm 0.44$) and in 44 females from 68 to 84 ($75.4 \pm 0.57$). Males have 35 to 47 ($40.2 \pm 0.27$) femoral pores; females, 31 to 42 ($37.3 \pm 0.37$). The supraorbital semicircle-series of granules is complete (that is they encircle the second, third, and fourth enlarged supraoculars) in 103 (76.4 per cent) specimens. In seven (5.1 per cent) the granules extend anteriorly to the anterior edge of the second supraocular; in 14 (10.2 per cent) they extend to the middle of the second supraocular; in 9 (6.1 per cent) they extend to the posterior edge of the second supraocular; in 3 (2.2 per cent) they extend to the middle of the third supraocular.

*Coloration.*—Notes on living and freshly killed specimens clarify ontogenetic and sexual dimorphism in color. The two hatchlings have a black dorsum with creamy white longitudinal lines. The lateral stripe is noticeably wider than the others. It passes through the upper part of the ear opening, over the insertion of the forelimb, and onto the anterodorsal insertion of the hindlimb. The dorsolateral stripe begins on the superciliaries and continues onto the dorsolateral sur-

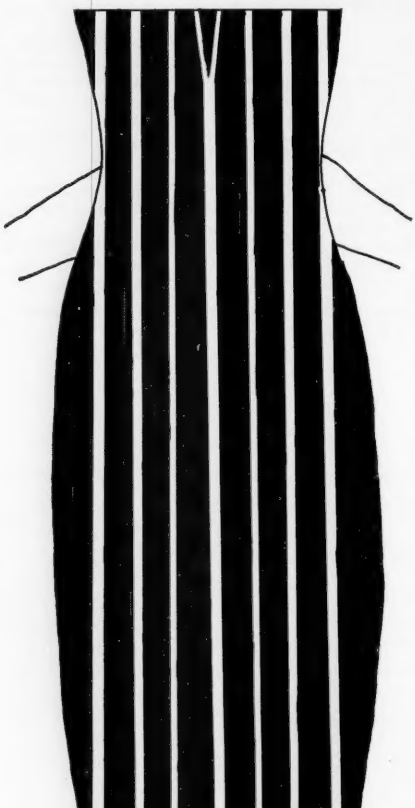

FIG. 1.—Dorsal color pattern (diagramatic) of hatchling *Cnemidophorus calidipes*, having a snout-vent length of 28 mm.

faces of the tail; the paravertebral stripe begins on the inner edge of the parietal and extends onto the base of the tail, where the paravertebrals fuse and form a single stripe on the proximal third of the tail. The vertebral stripes are fused in one hatchling and separate in the other. They begin on the parietal and terminate on the rump (Fig. 1). The limbs are dark brown mottled with cream; the tail is pale blue.

Females do not attain the color pattern displayed by large males. In large females spots are present in the dark fields; in some the spots are expanded to form short vertical bars on the flanks. In occasional specimens the stripes are partially fragmented, and the middorsal region is somewhat paler than the flanks. This color pattern, however, stands in strong contrast to the pale cocoa brown dorsum with bluish spots and vertical bars characteristic of adult males (Fig. 2). The ventral surfaces of females always are creamy white, whereas in males the belly is blue or black, and the throat is pink.

*Size*.—The largest male has a snout-vent length of 79 mm.; 25 males have snout-vent lengths of more than 70 mm. (average 73.8 mm.). Six females with snout-vent lengths of 66 to 68 mm. (average 67.2 mm.) are the largest examples of their sex. Two hatchlings with prominent umbilical scars have snout-vent lengths of 28 and 29 mm. and tail lengths of 52 and 50 mm.

## RELATIONSHIPS

Only *Cnemidophorus parvisocius*, known from southwestern Puebla and northern Oaxaca, approaches *calidipes* in size, scutellation, and coloration. Zweifel (1960:2) diagnosed *parvisocius* as having an average of 95 dorsal granules, maximum snout-vent length of 80 mm., an average of 40 femoral pores, and a dorsal pattern consisting of fragmented stripes and vertical bars on the flanks. Furthermore, *parvisocius* resembles *calidipes* in the anterior extent of the supraorbital semicircle series, a characteristic shared in the *sexlineatus* group of *Cnemidophorus* only by these species.

The areas from which *calidipes* and *parvisocius* are known both lie, at least in part, in the Balsas Basin, but these areas are about 450 kilometers airline distant. One juvenile female (UMMZ 117058) from Telolsaparu, Guerrero, has 80 dorsal granules around the body; the supraorbital semicircle series does not extend anteriorly. The assignment of this specimen is doubtful, but its presence does indicate the existence of a population of *Cnemidophorus* having a low number of dorsal granules in the vast area of the Balsas Basin between Tehuitzingo, Puebla, and the Tepalcatepec Valley in Michoacán.

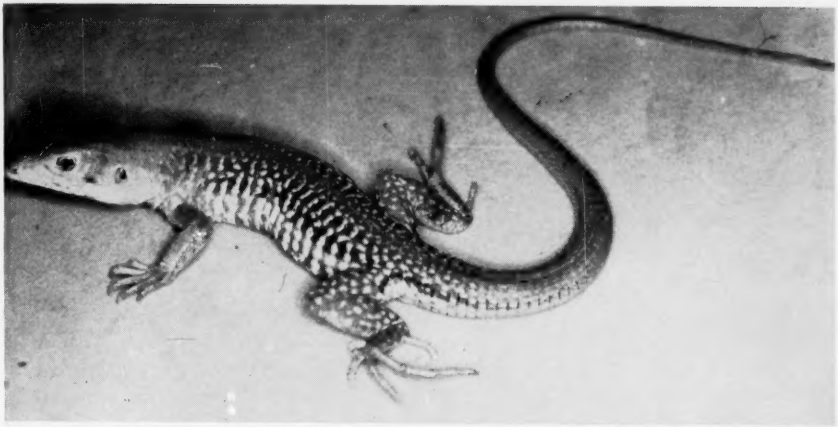

FIG. 2.—An adult male of *Cnemidophorus calidipes* from Capirio, Michoacán, showing characteristic adult color pattern.

## DISTRIBUTION

One specimen (KU 29747) is from the relatively arid, low Pacific slope of the Sierra de Coalcomán, 25 kilometers south of Arteaga in southern Michoacán. All other known specimens of *Cnemidophorus calidipes* are from the low, arid Tepalcatepec Valley, a part of the Balsas Basin in the state of Michocán. In this valley the lizards have been collected at elevations of between 200 and 650 meters above sea level. *Cnemidophorus lineatissimus exoristus*, a subspecies essentially restricted to the Tepalcatepec Valley, also has been collected south of Arteaga (Duellman and Wellman, 1959:00). The locality data for the 140 specimens examined are (all specimens from the state of Michoacán): Apatzingán, CNHM 38970, 109503–57; 12 km. S of Apatzingán, UMMZ 112686–8; 14 km. SSW of Apatzingán, KU 29748; 20 km. S of Apatzingán, CNHM 38973; 19 km. E of Aptzingán, NMMZ 114747 (5); 25 km. S of Arteaga, KU 29747; Capirio, UMMZ 112671–2, 114743 (17), 114746 (2), 119135 (9); 2.5 km. N of Capirio, UMMZ 114745 (4); 4 km. N of Capirio, UMMZ 112673–85, 114742 (3); El Espinal, UMMZ 119136 (13); 5 km. N. of Neuva Italia, UMMZ 114741; Río Jazmin, near Jazmin, UMMZ 114744 (9).

## ECOLOGY

*Cnemidophorus calidipes* lives in the low, arid valley of the Río Tepalcatepec in southern Michoacán. This valley lies roughly on an east-west axis and has a length of about 130 kilometers. The floor of the valley varies from about 200 to approximately 700 meters above sea level. Lying as it does in the rain shadow of the Sierra de Coalcomán, the Tepalcatepec Valley receives little rain, the annual rainfall seldom exceeds 800 mm., and the period of January through April sometimes is without rain. Temperatures are high throughout the year, and records of 43° C. have been reported from several stations in the valley.

The vegetation of the valley has been described by Leavenworth (1946). Data presented by him together with that I secured show that with the exception of the gallery forests along the major streams, the valley supports a low, xerophilous scrub forest of varying density. Typical trees in the more open scrub forest are *Acacia cymbispina, Apoplanesia paniculata, Cercidium plurifoliolatum, Crescentia alata, Guaiacum coulteri, Mimosa distachya, Prosopus juliflora,* and *Zizyphus sonorensis.* Even during the rainy season, when the trees are in full leaf, the trees provide little shade. During the dry season most of the trees are leafless; the ground cover consists only of sparse dead grasses as reminders of the previous rainy season (Fig. 3). Near streams the scrub forest is more dense. In these places some of the trees retain at least a part of their leaves throughout the year. With the notable exception of *Cercidium plurifoliolatum,* most of trees characteristic of the open scrub forest associate with *Bursera jorullensis, Caesalpina*

FIG. 3.—Habitat of *Cnemidophorus calidipes* near Capirio, Michoacán, in the dry season. The trees are *Apoplanesia paniculata, Ceridium plurifoliolatum,* and *Prosopus juliflora.*

*platyloba, Cordia eleganoides, Jaquinia pungens,* and others to form the dense scrub forest.

During the rainy season *Cnemidophorus calidipes* is a characteristic inhabitant of the open scrub forest, particularly the *Cercidium-Prosopus-Apoplanesia* associations on the rolling gravel plains where there is a sparse growth of grasses. In this habitat the lizards appear to be active throughout the day, with the exception of the relatively short cool time in the morning and during the afternoon showers. Although individuals frequently are seen in the dense scrub forest, usually they are not far from clearings or open forest. During the dry season, when there seldom is cloud cover and no shade provided by the leafless trees in the open scrub forest, *calidipes* is more frequently observed in the dense forest, which affords some protection from the rays of the sun.

In the scrub forest *calidipes* is associated with four other species of *Cnemidophorus*: *communis communis* in dense and open scrub forest, but primarily the former; *deppei infernalis* in the open scrub forest; *lineatissimus exoristus* in the dense forest; and *sacki*[1] (*auctorum*) in both dense and open scrub forest, but primarily in the latter. Both *communis* and *sacki* are large species; *lineatissimus* is of moderate size, and *deppei* and *calidipes* are small. *Cnemidophorus deppei* and *lineatissimus* belong to the *deppei* group, and the other three species are members of the *sexlineatus* group. Zweifel has already called attention to the ecological relationships of large and small species of the *sexlineatus* group in sympatric populations—*calidipes* and *sacki* in the Tepalcatepec Valley, and *parvisocius* and *sacki australis* in Oaxaca. The exact relationship of *communis* with *sacki* and *calidipes* in the Tepalcatepec Valley has yet to be determined; probably *communis* is a relatively recent immigrant into the valley from Colima (see Duellman, 1958:20).

The two small species, *calidipes* and *deppei,* seem closely associated ecologically. Limited observations indicate, however, that *deppei* prefers more riparian situations than does *calidipes*; for example, along the Río Cancita and Río Marquez *deppei* is abundant in the rather lush grass along the flood plains, whereas *calidipes* is absent there, but present in large numbers in the open scrub forest on higher ground, which also is oc-

[1] Actually, as will be shown by Duellman and Zewifel (in ms.), *sacki* is not the specific name properly applicable to the lizards of the Balsas Basin.

cupied by *deppei*. *Cnemidophorus calidipes* is associated with *sacki* throughout most of the valley, but *calidipes* appears to be more tolerant of open conditions than is *sacki*. There is insufficient information on *communis* in the Tepalcatepec Valley to comment on its ecological relationships with *calidipes*. Only at Capirio in dense scrub forest were *calidipes* and *lineatissimus* found together.

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MUSEUM OF NATURAL HISTORY, THE UNIVERSITY OF KANSAS, LAWRENCE.

# *Potamarius*, a new Genus of Ariid Catfishes from the Fresh Waters of Middle America[1]

CARL L. HUBBS AND ROBERT RUSH MILLER

INCREASING knowledge of the fish fauna of the peninsula-like connection between North and South America supports the concept of a distinctive Middle American fauna (Miller, 1959). Within this area great richness and diversity characterize the widespread Poeciliidae and, in a more limited region, the endemic family Goodeidae; also, to a lesser extent, cichlids referred to *Cichlasoma* and derived genera, freshwater atherinids (especially *Chirostoma*), and pimelodid catfishes of the genus *Rhamdia*. Although endemic genera and species of ictalurid catfishes have been described from México, no indigenous genus of the essentially marine Ariidae has heretofore been named from Middle America.

In addition to derivatives of immigrants from Nearctic and Neotropical regions, the faunally unsaturated fresh waters of Middle America have become populated by fishes from adjacent marine waters. Notable among these are the atherinids and very possibly the goodeids, already mentioned, and a considerable number of representatives of other families, including at least two hemiramphids, a peculiar gerrid described as *Gerres mexicanus* Steindachner, several eleotrid gobies and several pipefishes (Syngnathidae), the endemic toadfish (*Batrachoides goldmani* Evermann and Goldsborough), and several clingfishes of the genus *Gobiesox* (Briggs and Miller, 1960). In addition to the wholly or essentially freshwater species *Arius melanopus* Günther, with subspecies *A. m. melanopus* and *A. m. aguadulce* (Meek), the marine Ariidae have contributed to the Middle American freshwater fauna the peculiar genus herein described.

The new genus comprises two species, one of which has been misplaced by most workers in the South American pimelodid genus *Conorhynchos*. Breder (1935:161–162), however, referred it to the Ariidae, and Gosline (1945:9), on the advice of the senior author, indicated that it represents a distinct genus of that family.

***Potamarius**, gen. nov.*

*Type species.*—*Conorhynchos nelsoni* Evermann and Goldsborough, 1902.

[1] Contributions from the Scripps Institution of Oceanography, New Series, and from the Museum of Zoology of the University of Michigan.

*Diagnosis.*—Ariid catfishes having the minute conical teeth restricted to rather short villous bands on premaxillaries and dentaries; the snout particularly narrow, depressed, and elongate (as long as or longer than the postorbital), not at all gibbous, produced, or elevated above the thick upper lip; lower jaw sharply included, with heavy lips; mouth narrow and small, with essentially transverse gape; barbels (one maxillary pair and two mental pairs) short; eye small, above middle of head; gill-membranes broadly V-shaped, but with a wide free border medially; rakers of moderate length and number (14 to 18 on first arch, with 8 to 11 below the angle); dorsal with strong spine, smooth along front and with obsolescent denticulations behind (the minute denticulations barely project out of the posterior furrow of the spine), and with 6 soft-rays (the last double); adipose moderately large, originating somewhat behind the anal origin; anal fin short and high, with 15 to 21 rays; principal caudal rays $7 + 8 = 15$; pectoral rays I, 10 (rarely I, 9); pelvic rays 6; vertebrae 52 to 54 (including five modified vertebrae and the hypural complex).

*Range.*—Quiet fresh waters of Middle America: through the Río Usumacinta system of Guatemala and México and in Lago de Izabal on the east coast of Guatemala (Fig. 6).

*Distinction from Conorhynchos.*—*Potamarius* differs from *Conorhynchos,* in which South American pimelodid genus the type species (*nelsoni*) has almost consistently been misplaced, in many features of major systematic import (the comparison is made with a single adult female of *Conorhynchos conirostris* (Valenciennes), 402 mm. in standard length, UMMZ 147403, from lakes of Caripós, Pernambuco, Brazil). The anterior and posterior nostrils of each side are much less widely separated, by an interval only about as great as the length of either nostril, with no intervening bone; the principal caudal rays number 15 ($7 + 8$) instead of 17 ($8 + 9$); there is a transverse system of lateral-line neuromasts, which is lacking in *Conorhynchos* and all other pimelodids; the ovaries are more baglike and the ova are few and extremely large, instead of numerous and minute; the pelvic fin of the female is modified for the transfer of the eggs into the mouth of the male; there is an axillary pore (lacking in *Conorhynchos*); the body posteriorly is subterete instead of sharply compressed; the anal fin is shorter and relatively higher; the adipose fin originates over the front rather than the rear part of the anal base; the serrulations of the dorsal spine are obsolescent; the dorsal soft-rays number 6 instead of 5 (last two elements counted as one ray); the muzzle though narrow is depressed and straight, instead of being tubelike and decurved; the gill-membranes medially are broadly V-shaped instead of abruptly U-shaped and have a well-developed rather than incipient free fold. The resemblances in the edentulous palate, long and narrow snout, thick lips, small mouth, and short barbels are surely minor convergences, not indicative of direct phylogenetic relationship. Several of the trenchant differences denote not only generic but also family separation.

*Reference to Ariidae.*—*Potamarius* agrees with the diagnoses of the Ariidae by Regan (1911:557–558) and by Weber and de Beaufort (1913:271), but not with that of Berg (1940:447), since the palate is not toothed. But this region is edentulous also in several genera of certain Old World regions, for example, India (Day, 1878–88:440–468), the East Indies (Weber and de Beaufort, 1913: 272), and Thailand (Smith, 1945:404). Characteristics of the Ariidae, all shared by both species of *Potamarius,* include: (1) the anterior and posterior nostrils of each side are separated only by the respective valves and a narrow bridge of boneless tissue; (2) there are no nasal barbels; (3) oral gestation is practiced by males (in most if not all species of the family); (4) in correlation with the oral gestation, the buccal cavity of the males becomes greatly enlarged (Fig. 1); (5) the pelvic fins of the mature females are modified by hard, transitory protuberant ridges that presumably facilitate the passage of the eggs from the oviduct to the mouth of the males; (6) the ovaries are baglike and the ova are relatively immense; (7) transverse branches of the lateral line are marked by single files of neuromasts, and in life by rows of silvery specks (Fig. 2) that run across the body above and below; and (8) the gill-membranes are united, and are attached to the isthmus so as to leave a wide, free fold. The 6-rayed pelvics may be another, but not exclusive family character, and some of the other ray numbers, particularly of the caudal and dorsal soft-rays, may prove to have broad systematic value. As a group, the ariids occur chiefly along sandy and muddy shores and in coastal lagoons and estuaries, in tropical and subtropical regions. Some species freely enter fresh waters and a few, like the two species

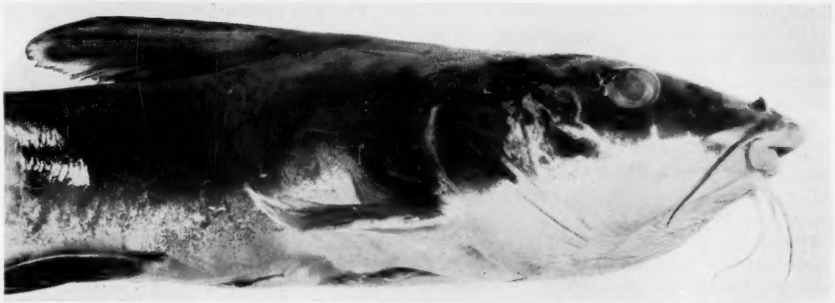

FIG. 1.—Lateral view of anterior parts of a brooding male of *Potamarius izabalensis* (USNM 134346), 313 mm. long. Photograph by Smithsonian Institution.

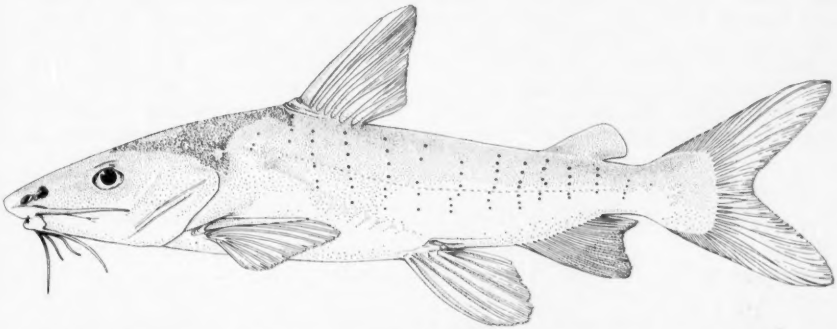

FIG. 2.—*Potamarius izabalensis*, new species. Lateral view of holotype, a female 386 mm. in standard length (the spots were added from a juvenile, with paper tag no. 16, USNM 179837, 286 mm. long).

of *Potamarius*, seem to be permanently restricted to fresh water.

*Comparison with other ariid genera.*—*Potamarius* is readily distinguishable from all previously established New World genera of Ariidae by its edentulous palate, narrowed and elongate snout, thick lips, small mouth, and short barbels—the characters in which it and *Conorhynchos* are convergent. From Old World genera with an edentulous palate, as described by Weber and de Beaufort (1913:272–329), it is also obviously distinct; and we assume that it originated independently from a different species of *Arius*, or from a genus closely related to *Arius*.

From *Katengus* it differs sharply in the essentially transverse, anterior, and smallish mouth, with the gape not nearly reaching to below the eye, and in having bands of minute conical teeth on the jaws, rather than a single series of incisors.

From *Tetranesodon* it is separated by having definite bands of many teeth instead of a small patch of a very few teeth on each side of each jaw; a flat rather than rotund and produced snout; and a scarcely serrulate dorsal spine.

From *Nedystoma* it is distinguished by having the teeth in bands instead of 1 or 2 series; only 8 to 11 shortish rakers instead of more than 20 long ones on the lower limb of the first arch; and the gill-membranes with a free posterior border.

From *Hemipimelodus*, which it seems to resemble most closely in such characters as dentition, it differs in having the snout flat, instead of being gibbous and more or less prominent or even projecting beyond the upper lip; the denticulations of the dorsal spine obsolescent; the free border of the gill-membranes wide medially; and the origin of the adipose fin somewhat behind rather than over or before the anal origin.

From all or nearly all Old World species of *Arius*, or of other closely related genera with teeth on the palate, if these be sepa-

rated, the species of *Potamarius* differ further in the narrowness and/or the production of the snout. In one or the other of these respects some of the Old World forms do approach *Potamarius*. For example, the Indian species *Arius burmanicus* (Day) has the much depressed snout as long as in *Potamarius nelsoni*, but its snout is broad and the species is otherwise very different (Day, 1878–88:458, pl. 105, fig. 4).

In all probability trenchant osteological characters will be found to distinguish *Potamarius* from other ariid genera. Numerous cranial differences between *P. nelsoni* and *Galeichthys felis* are evident (pp. 109–110).

*Etymology.*—The name *Potamarius* is derived from ποταμός, river, and *Arius* (probably from the Greek αριος, a warrior, through the Latin *Arius*). The gender is masculine.

*Species.*—In addition to *Potamarius nelsoni* (Evermann and Goldsborough), the type species, we find that the genus contains another species, here described as *P. izabalensis*. The two are distinguished by the several characters outlined in Table I.

***Potamarius izabalensis, sp. nov.***

(Figs. 1–4, 6)

*Holotype.*—USNM 134347, an adult female 386 mm. in standard length (Fig. 2), collected by Robert R. Miller and Ancil D. Holloway in Lago de Izabal, Guatemala, on April 6–7, 1946. It was caught on a 100-yard trot-line set overnight on the north shore of the lake about 1 mile west of El Paraíso, at a depth of not over 5 feet. Field tag U42-602, collection M46-43.

*Paratopotypes.*—USNM 134346, 8 immature to adult specimens (males and females), 254–394 mm. long to caudal base, from gillnets set in Lago de Izabal near the mouth of Río Polochic, 5:30 to 8:30 P.M., April 7, 1946, by Miller and Holloway. UMMZ 177251, 5, immature to adult, males and females, 190–370 mm. long, with same data.

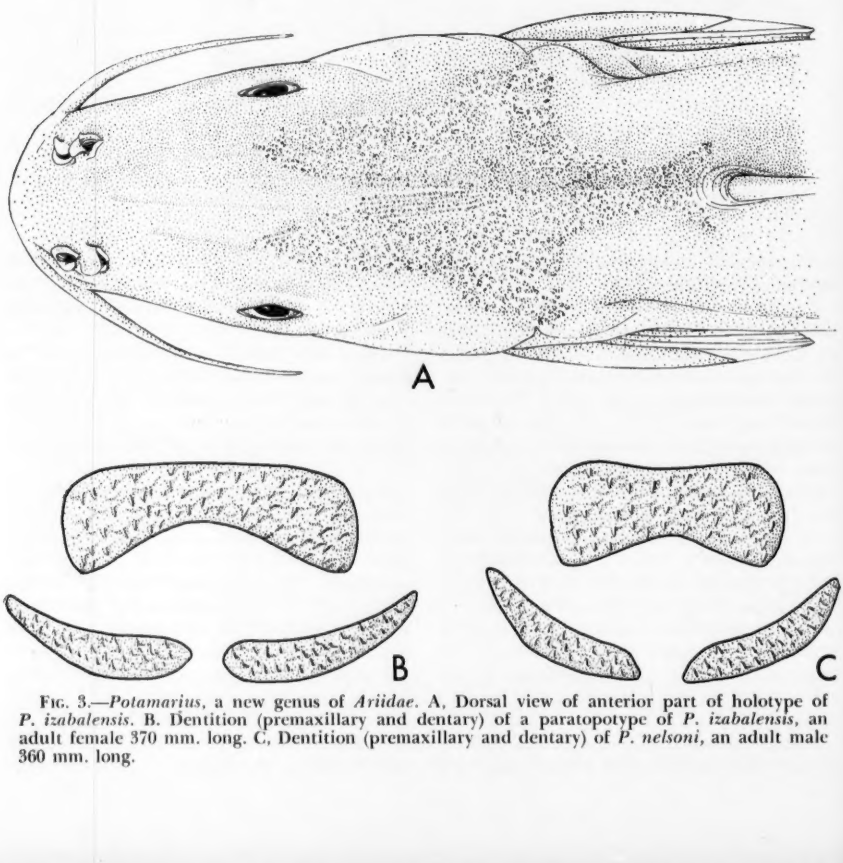


FIG. 3.—*Potamarius*, a new genus of *Ariidae*. A, Dorsal view of anterior part of holotype of *P. izabalensis*. B. Dentition (premaxillary and dentary) of a paratopotype of *P. izabalensis*, an adult female 370 mm. long. C, Dentition (premaxillary and dentary) of *P. nelsoni*, an adult male 360 mm. long.

TABLE I

COMPARISON OF THE TWO SPECIES OF *Potamarius*

Proportional measurements are for subadult and adult specimens less than 400 mm. in standard length. For details see Table II.

| Character | *P. izabalensis* | *P. nelsoni* |
|---|---|---|
| Gill-rakers, lower limb | 9, seldom 8 or 10 | 10, occasionally 11 |
| Gill-rakers, total | 14 to 16 | 16 to 18 |
| Maxillary barbel | Longer, extending posteriorly beyond eye; 1.65 to 2.1 in head length | Shorter, not extending posteriorly beyond middle of eye; 2.25 to 2.8 in head length |
| Snout into postorbital | 0.9 to 1.05 | 0.7 to 0.9 (0.9 in 1 specimen) |
| Dorsal spine into head | 1.3 to 1.9 | 1.8 to 2.3 |
| Pectoral spine into head | 1.55 to 2.0 | 2.05 to 2.4 |
| Average differences: | | |
| Head length | 3.05 to 3.45 | 2.8 to 3.25 |
| Predorsal length | 2.35 to 2.7 | 2.25 to 2.55 |
| Interorbital | 2.5 to 3.05 | 2.8 to 3.25 |
| Adipose base | 3.2 to 3.95 | 3.0 to 3.5 |
| Head width | 1.5 to 1.7 | 1.6 to 1.85 |
| Distribution | Lago de Izabal, Guatemala, and probably the lower Río Polochic | Lakes and quiet portions of large rivers in the Río Usumacinta basin, Guatemala (El Petén, Alta Vera Paz) and México (Tabasco, Chiapas) |

USNM 139837, 3, 1 immature, 2 females, 286–440 mm., with same data as holotype. USNM 134348, 1 immature, 217 mm., from north shore of Lago de Izabal (gill-net in embayment about 3 miles west of El Estor), between 7:30 P.M. and 8:30 A.M., April 8–9, 1946, Miller and Holloway. USNM 114500, 22 young, from mouths of brooding males secured in gill-nets in Lago de Izabal, April 24–28, 1947, Miller and Holloway. UMMZ 177252, 2 young, with same data (Fig. 4).

The record stations, defining the distribution of the species, are shown on Fig. 6.

*Diagnosis.*— A species of *Potamarius* distinguished from its only known close relative, *P. nelsoni*, by its larger tooth patches (Fig. 3), fewer gill-rakers on the lower limb and in total count (Table I), and in various proportions (Tables I–II): rather consistently, the maxillary barbel is longer (in half-grown and adult specimens this barbel, when pressed backward against the head, reaches well behind the eye in 15 specimens of *P. izabalensis* and just beyond the eye in 2, whereas in *P. nelsoni* the barbel reaches back to any point from just in front of orbit to middle of orbit); the snout is shorter; the dorsal and pectoral spines are longer and heavier; on the average, with a wide overlap, the head, the predorsal length, and the adipose base are shorter; and the interorbital and head are less excessively narrowed as compared with most ariids (the head width varies widely, from slightly to much greater than maximum head depth). In most respects, *P. izabalensis* appears to be less extreme and more primitive than *P. nelsoni*.

*Additional characters.*—Several of the characters of *P. izabalensis* that are not specific are indicated in the account of the genus. The general body form and proportions of the adults, the dentition, and the appearance of the young, are well portrayed on Figs. 1–4. Proportional measurements are indicated in Table II. Sexual dimorphism in proportions is evident only in the greater length of the pelvic fins in females, and in the enlarged buccal cavity of brooding males (Fig. 1).

*Meristic counts.*—Dorsal invariably I, 6 (in the dorsal and anal fins the last two elements, approximated but separate at the base, are counted as a single ray). Anal 16–21 (in the 24 newborn young and in some of the larger specimens the count was determined from radiographs; in the remainder, a precise count was insured by incising the skin at the fin base). The counts were constant in the other fins: caudal (principal rays)

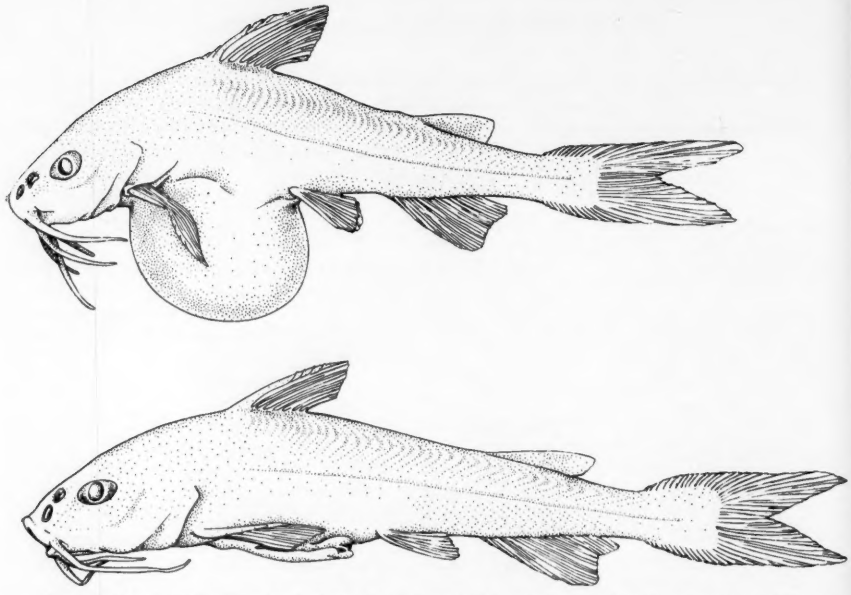

FIG. 4.—Young of *Potamarius izabalensis*, 45.0 and 51.5 mm. long, taken from mouths of brooding males.

TABLE II

PROPORTIONAL MEASUREMENTS OF TWO SPECIES OF *Potamarius*

The ratios were obtained by stepping the given measurement over the curve of the body or head with dividers, under appropriate magnification.

| Item | *Potamarius izabalensis* | | | *P. nelsoni* | |
|---|---|---|---|---|---|
| Standard length in mm. | 386[1] | 190–394 | 440 | 138 | 276–388 |
| Sex and no. of specimens | ♀ | 4 ♂s, 6 ♀s, 7 imm. | ♀ | imm. | 6 ♂s, 4 ♀s, 7 imm. |
| Into standard length: | | | | | |
| Head length | 3.1 | 3.05–3.45 | 3.0 | 3.75 | 2.8–3.35 |
| Body depth | 5.0 | 4.5–5.1 | 4.5 | 5.3 | 4.3–5.3 |
| Predorsal length | 2.4 | 2.35–2.7 | 2.4 | 2.8 | 2.25–2.6 |
| D origin to adipose origin | 2.8 | 2.5–2.9 | 2.5 | 2.55 | 2.5–2.95 |
| A origin to C base | 3.6 | 3.2–3.6 | 3.75 | 2.95 | 3.3–3.6– |
| Into head length: | | | | | |
| Snout length | 2.15 | 2.1–2.3 | 2.1 | 2.25 | 2.0–2.15 |
| Maxillary barbel | 2.0+ | 1.65–2.1 | 2.0+ | 1.75 | 2.25–2.8 |
| Least fleshy interorbital | 2.65 | 2.5–3.05 | 2.5 | 3.35 | 2.8–3.25 |
| Dorsal spine | 1.9 | 1.3–1.9 | 2.1– | 1.8 | 1.8–2.3 |
| Pectoral spine | 2.0+ | 1.55–2.0 | (2.5–)[2] | 1.95 | 1.8–2.4 |
| Dorsal base | 3.35 | 2.8–3.2 | 3.2 | 2.4 | 2.8–3.6 |
| Adipose base | 3.9 | 3.2–3.95 | 4.3+ | 2.4 | 3.0–3.5 |
| Anal base | 2.5 | 2.0–2.5 | 2.7 | 1.5 | 1.95–2.6 |
| Head width | 1.65 | 1.5–1.7 | 1.75 | 1.6 | 1.6–1.85 |
| Pelvic length | | | | | |
| Males[3] | ... | 2.0–2.05 | ... | ... | 1.95–2.2 |
| Females[4] | 1.5 | 1.5–1.6 | 1.6– | ... | 1.55–1.7+ |
| Into postorbital length: | | | | | |
| Eye length | 3.6 | 2.4–3.7 | 4.0 | 1.65 | 2.5–3.6 |
| Snout length | 0.95 | 0.9–1.05 | 0.95 | 0.75 | 0.7–0.9 |

[1] Holotype.
[2] The pectoral spine in this large specimen is interpreted as having been broken.
[3] In 4 males of *P. izabalensis* 301–320 mm. long, and in 6 males of *P. nelsoni* 317–385 mm. long.
[4] In 6 females of *P. izabalensis* 287–440 mm. long, and in 4 females of *P. nelsoni* 295–388 mm. long.

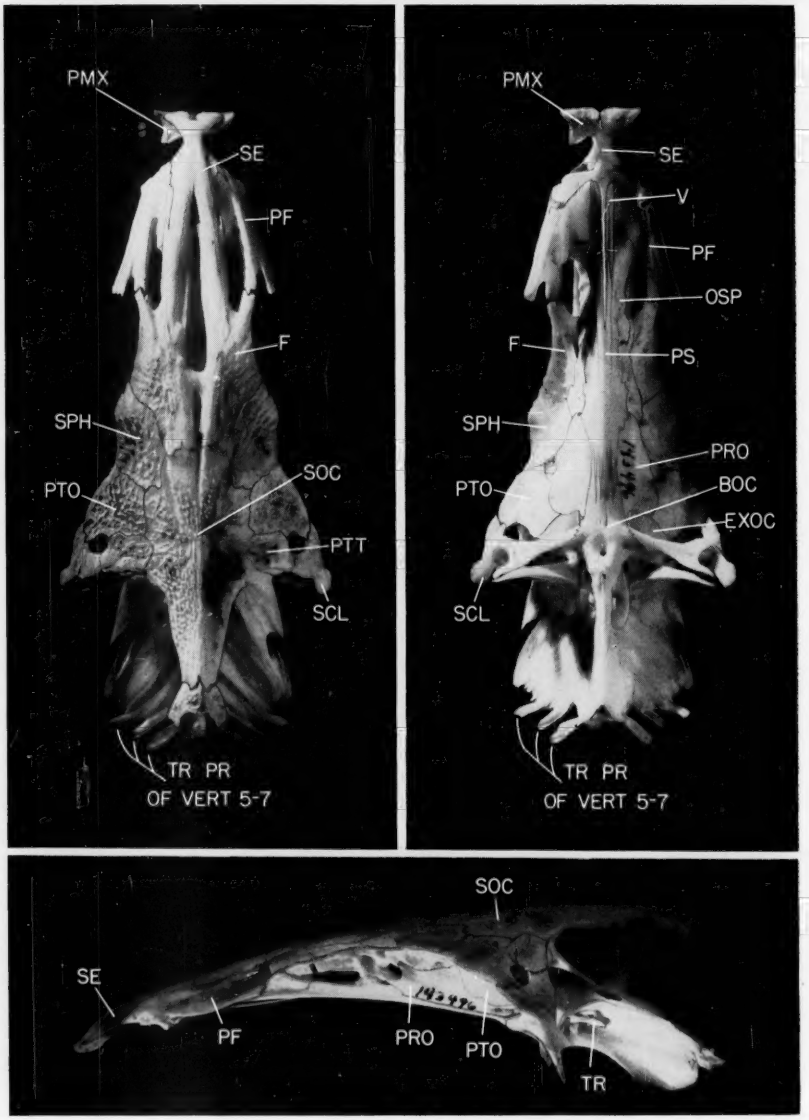


PLATE I

*Potamarius nelsoni*. Skull of adult (UMMZ 143496—S in dorsal, ventral, and lateral views (overall length of skull 143 mm.). BOC, Basioccipital; EXOC, exoccipital; F, frontal; OSP, orbitosphenoid; PF, prefrontal; PMX, premaxillary; PRO, prootic; PS, parasphenoid; PTO, pterotic; PTT, posttemporal; SCL, supracleithrum; SE, supraethmoid; SOC, supraoccipital; SPH, sphenotic; TR, tripus; TR PR, transverse process; V, vomer.

7 + 8 = 15; pectorals I, 10; pelvics 6. Gill-rakers 5 to 7 + 9 or 10 = 14 to 16 (5 + 9 = 14 in one, 6 + 9 = 15 in twelve, 6 + 10 = 16 in one, 7 + 9 = 16 in three). Vertebrae 52 (3), 53 (13), 54 (2), in 18 (4 adults and 14 young), counting the vertebrae incorporated into the Weberian apparatus as 5 and including the hypural complex as one vertebra (the greatly expanded bialate transverse process is interpreted, as it was by Gregory (1933: fig. 79 on p. 193), as pertaining to the fourth vertebra).

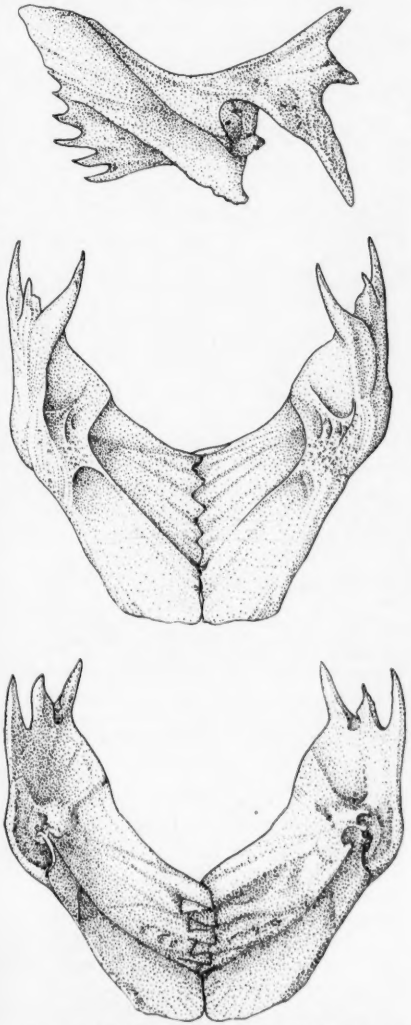

FIG. 5.—*Potamarius nelsoni*. Cleithrum of adult (UMMZ 143496—S) in three views for comparison with figures for *Galeichthys felis* given by Merriman (1940: fig. 8).

*Range*.—So far as known this species is confined to Lago de Izabal, including a distributary of the Río Polochic. It no doubt occurs in the lower reaches of that stream.

*Associates*.—The fish fauna of Lago de Izabal is now known to total 48 species, referable to 38 genera (Holloway, 1950:114, in listing 37 genera, entered *Carlhubbsia* as *Phallichthys* and omitted *Diapterus*). Eleven of the species (23 percent) are endemic. Although fresh, except possibly at its mouth near San Felipe (Holloway, 1950: map 2), the lake contains such marine types as a shark, a sawfish, tarpon, anchovies, needlefish, a sparid, a croaker, and numerous gobbies.

Lago de Izabal is inhabited by five species of catfishes: *Galeichthys assimilis* (Günther), *Arius melanopus* Günther, *Bagre marinus* (Mitchill), and *Potamarius izabalensis*—all of the Ariidae—and *Rhamdia guatemalensis* (Günther), of the Pimelodidae. None is eaten by the natives, who shun scaleless fishes, although ariids are excellent food. *P. nelsoni* is relished by the natives in El Petén and in México, and was regarded by E. W. Nelson as the best freshwater food fish in México (Evermann and Goldsborough, 1902:146). The tastiness of the species of *Potamarius* has been verified by the authors. All the species except *Rhamdia guatemalensis* were taken in experimental gill-nets, on trot-lines, or in a 600 × 16 foot commercial seine (*Rhamdia* was caught in smaller seines; *Bagre* was the least abundant).

Lago de Izabal is also inhabited by a shrimp, *Palaemon pandaliformis* (Stimpson), which ranges widely in fresh and brackish waters of the tropical western Atlantic (identification and information furnished by L. B. Holthuis and Fenner A. Chace, Jr.).

### *Potamarius nelsoni* (Evermann and Goldsborough)
### (Pl. I and Figs. 3C, 5–6)

*Conorhynchos nelsoni*.—Evermann and Goldsborough, 1902:140–146, fig. 1 (original description; oral brooding; "Rio Usumacinta, Montecristo, Yucatan [=Tabasco]." Meek, 1904:19, fig. 3 (description and figure; "Atlantic streams from Chiapas to Brazil"). Eigenmann, 1910:390 ("Rio Usumacinta, Montecristo, Chiapas"). Jor-

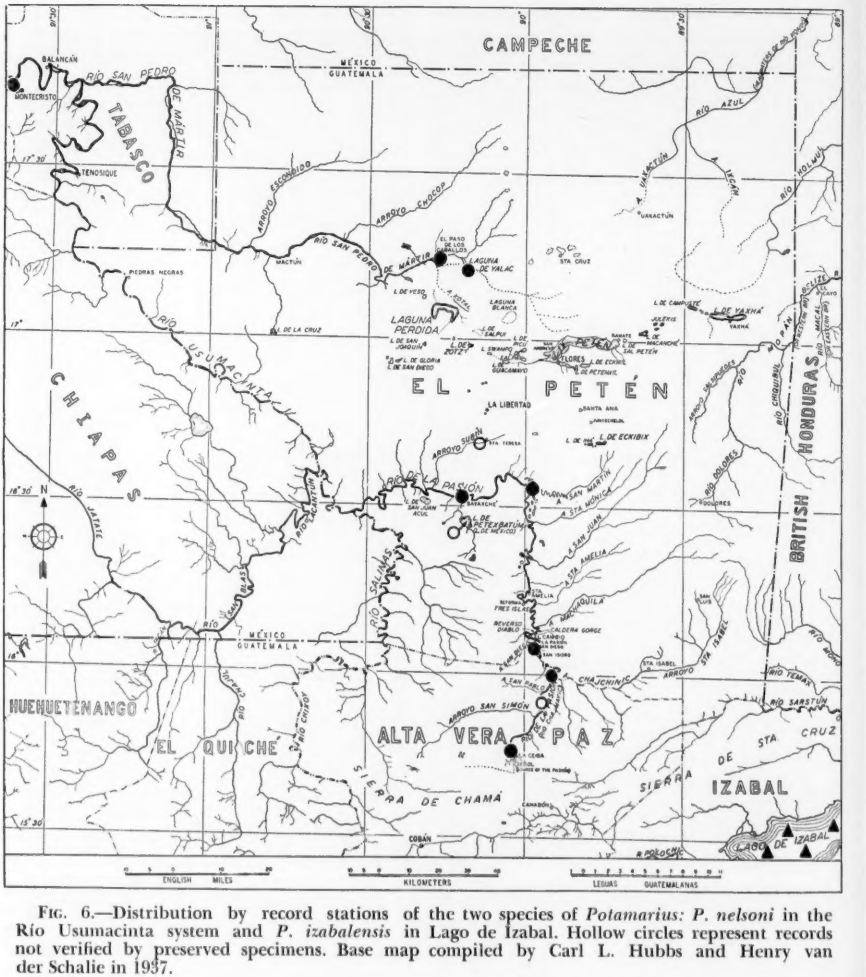


FIG. 6.—Distribution by record stations of the two species of *Potamarius: P. nelsoni* in the Río Usumacinta system and *P. izabalensis* in Lago de Izabal. Hollow circles represent records not verified by preserved specimens. Base map compiled by Carl L. Hubbs and Henry van der Schalie in 1937.

dan, Evermann and Clark, 1930:156 ("Rio Usumacinta, Yucatan"). De Buen, 1940:26 ("Rio Usumacinta, en Montecristo, Chiapas"). Alvarez, 1950:34 (characters in key; "Rio Usumacinta").

*Conorhynchus nelsoni*.—Regan, 1906–08:138 (characters; Rio Usumacinta in Chiapas). Breder, 1935:161–162 (referred to Ariidae).

. . . . . *nelsoni*.—Gosline, 1945:9 ("Chiapas, México").

*Material*.—This species has been recorded in the literature only on the basis of the type material from the Río Usumacinta in Tabasco, México. The type locality was misplaced as in "Yucatan" by Evermann and Goldsborough and by Jordan, Evermann, and Clark, and as in "Chiapas" by Meek, Regan, Eigenmann, Gosline, and de Buen. Misled by the erroneous reference of the species to the Brazilian genus *Conorhynchos*, Meek indicated the range of *nelsoni* as "Atlantic streams from Chiapas to Brazil." (For references see synonymy.)

In 1935 the senior author and Henry van der Schalie collected in Guatemala 19 additional specimens (all in the University of Michigan Museum of Zoology), as follows: 143496, 2 adult males 360 and 388 mm. in

standard length, and skeleton of one adult (prepared in field), saved from several caught in gill-net in Río de la Pasión across and near mouth of Arroyo del Petexbatum, Sayaxché, El Petén, April 22–24. 143497, 1 half-grown and 1 adult female, 138 and 388 mm. long (one still larger escaped), from gill-net in mouth of Arroyo Chajchinic (tributary to Río de la Pasión), on line between El Petén and Alta Vera Paz, April 17–18. 143498, 8 half-grown to adult, 195 and 276–322 mm. long, from gill-net and trot-line in Laguna de Yalac, in course of Río San Pedro de Mártir, about 6 leagues by river above El Paso de los Caballos, El Petén, March 16–17. 144267, 1 adult female, 342 mm. long, from gill-net in Río de la Pasión, at San Diego, on line between El Petén and Alta Vera Paz, between El Cambio and Chajchinic, May 18. 144269, 1 subadult male, 306 mm. long, 1 adult male 336 mm. long, and 1 adult female 362 mm. long (1 other discarded in field), from gill-net in Río de la Pasión near head, at Ceiba, Alta Vera Paz, April 10–12. 144270, 1 adult female, 295 mm. long, from gill-net in lagoon-like arm of Río San Pedro de Mártir, at El Paso de los Caballos, El Petén, March 10–12. 144271, 1 adult male 318 mm. long, from gill-net about junction of Arroyo San Martín with Río de la Pasión, east of Sayaxché, El Petén, April 21–22.

*Proportional measurements.*— Measurements of *Potamarius nelsoni* are presented in comparison with those of *P. izabalensis* in Tables I and II. Oddly, the head seems to increase in relative length with age. Marked sexual dimorphism in proportions seems to be restricted to the enlarged buccal cavity of brooding males and the enlarged pelvic fins of adult females.

*Meristic counts* (18 specimens).—Dorsal invariably I, 6. Anal 15–20. Caudal (principal rays) invariably 7 + 8 = 15. Pectorals I, 10 (except I, 9 in one). Pelvics invariably 6. Gill-rakers 6 or 7 + 10 or 11 = 16 to 18 (6 + 10 = 16 in fifteen, 6 + 11 = 17 in two, 7 + 11 = 18 in one). Vertebrae 52(7), 53(3), 54(4) (counted as for *P. izabalensis*).

*Skeletal characters.*—The proportions and form of the skull are shown in Plate I, which illustrates its distinctively narrow anterior parts and its markedly domed outline. On comparison with a skull of the same length of *Galeichthys felis*, numerous striking differences are apparent. The comparison is made between a skull of *Potamarius nelsoni* (UMMZ 143496–S) from Río de la Pasión at Sayaxché, El Petén, and one of the same length of *G. felis* (University of Miami Marine Laboratory, no. 601) from Biscayne Bay, Florida, supplemented by the skeleton of a smaller specimen from the same locality, by Merriman's (1940) text and figures of the skeletons of *G. felis* and *Bagre marinus*, and by Gregory's (1933:197, fig. 79) account of the skull of *Arius* sp. In part we follow the conventional osteological nomenclature used by Merriman, and in part the newer terms advocated by Harrington (1955).

In dorsal view the skull of *Potamarius nelsoni* differs trenchantly from that of *Galeichthys felis* in the following respects, among others: (1) The median fontanelle is divided by a bridge of bone into a smaller posterior part as it is in *Bagre marinus*, as figured by Merriman, but with less closure. (2) The prefrontals (lateral ethmoids) are narrow and elongate, lack conspicuous anterior wings, and project backward almost to opposite the posterior end of the anterior lateral foramina. (3) The suture between prefrontal and frontal, just outside the anterior lateral foramen, remains open. (4) The posterior lateral foramina (between pterotic, posttemporal, and supracleithrum) are well developed, rather than absent; these foramina are indicated as present in *B. marinus*, though smaller than in *P. nelsoni*. (5) The supraethmoid (dermethmoid) is much narrower than in *G. felis* and is less arched in anterior profile.

In ventral aspect other differences appear: (6) The premaxillaries are much more expanded posteriorly. (7) The lateral wing of the vomer (prevomer) bridges over, on each side in the frontal plane, a conspicuous opening not present in *Galeichthys felis*. (7) The long needle-like shaft of the vomer is not fused with the parasphenoid posteriorly nor with the interdigitating parasphenoid and supraethmoids anteriorly, and the vomer is elsewhere delimited by distinct sutures, whereas in *G. felis* the shaft of the vomer and the posterior processes of the supraethmoid are fused with the parasphenoid, and the vomer elsewhere is almost completely anchylosed with the surrounding bones. (8) The prefrontal has an anterolateral expansion with a small elongate condyle unrepresented in *G. felis*, and the posterolateral margin of the supraethmoid forms a narrow and strongly curved definitive condyle, rather than an irregular articulating surface. (9) Medially the several bones of the skull are not expanded into conspicuous wings such as are developed in *G. felis*. (10) The fused

Weberian complex bears a midventral keel that is not evident in *G. felis*. There are many other, detailed differences.

How many of these characters will prove useful in generic analysis can not be assured, pending a more complete osteological survey of the family.

*Range (Fig. 6) and habitat.*—*Potamarius nelsoni* no doubt inhabits most of the larger and medium-sized streams of the Río Usumacinta system. In addition to the type locality (Montecristo—also called Emiliano Zapata) on the lower Usumacinta in eastern Tabasco, México, we report the species, on the basis of specimens, from Laguna de Yalac on the upper Río San Pedro de Mártir and from various points on the Río de la Pasión in El Petén and Alta Vera Paz in Guatemala. In addition, we can record reports of the occurrence of this locally well-known species in Arroyo Subín (a northern tributary of the Pasión) and in Laguna de Petexbatum (south of Sayaxché). A large adult escaped from a net set in Río de la Pasión between the mouths of arroyos San Pablo and San Simón. It was not taken and presumably does not occur in smaller creeks, nor in Laguna de Petén, where extensive collections were made. In February, 1959, Sr. Jorge Carranza (Director of the Estación de Biología Marina, Veracruz) told one of us (R.R.M.) that the species does not occur in Laguna de Términos, Campeche (near the mouth of the Río Usumacinta), where he has studied the catches of commercial fishermen. It may avoid the coastal lagoons in general.

In the lakes and larger streams within its range, *P. nelsoni* exhibits little habitat selection. Where it was taken the water varied from rather silty to clear, in color from chalky blue (in the Pasión) to blackish (in Laguna de Yalac) and opaque olive-yellow. The bottom graded from bedrock to soft mud and clay; the vegetation was absent to scanty; the depth varied from about 1 to 7 meters.

*Habits and vernacular names.*—At Laguna de Yalac in March, 1935, the senior author noted that *Potamarius nelsoni*, like other ariids, is adept at noise production. Here both this species, locally known as "curuco" (likely an onomatopoetic word) and *Arius melanopus* Günther (which is known throughout El Petén as "cabeza-fierro"—equivalent of "steelhead"), were heard producing a "quack" with the pectoral spine, as well as a "ronk," which is issued from their mouths. Both noises were often produced simultaneously, with one compound twitch. The "quack" is higher in pitch than the "ronk," and both noises are higher in pitch in the "curuco" than in the "cabeza-fierro." *Ictalurus meridionalis* Günther, known in El Petén as "bo-bo" (obviously onomatopoetic), also "quacks" and "ronks." the "bo-bo" has a quick, relatively soft "quack," and its "ronk" is not so loud as that of the two other siluroids. The *Ictalurus* is known in Río de la Pasión also as a "jolote."

At the source of the Río de la Pasión the senior author obtained from Don Carlos Vidaurre and his Indian laborers the Quiché names of the common fishes, including "box" for both ariids and "lu" for the *Ictalurus*.

Buccal brooding by this species was reported by Evermann and Goldsborough (1902) and was observed on the Río de la Pasión on April 22–24, when a very dark male was found to have embryo-containing eggs in its strikingly enlarged buccal cavity.

The nocturnal activity of this fish is suggested by the fact that most specimens were taken in overnight gill-net sets.

## Nomenclatural Remarks on the Family Ariidae and on the Genus *Conorhynchos*

Most authors have named the major family of marine catfishes Ariidae, but some have applied the name Tachysuridae (based on *Tachysurus* Lacépède, 1803). We reject that name in favor of Ariidae (based on *Arius* Valenciennes, 1840), for the sound reasons given by Regan (1906–08:125–126). In effect, the fish to which the name *Tachysurus* has been applied is unidentifiable from the original description, which is based solely on a Chinese painting. Its generic status, therefore, apparently can not be determined.

Some nomenclatural complications have arisen regarding the generic name *Conorhynchos*, which was established by Bleeker in 1858, with *Pimelodus conirostris* Valenciennes of Brazil as the type species. Regan (1906–08:138) used the spelling *Conorhynchus*, proposed by Bleeker (1862:12) as an emendation of *Conorhynchos*. Both Regan and Neave (1939, *Nomenclator Zoologicus*, 1:822) cited a later paper by Bleeker (1863, *Ned. Tijdschr. Dierk. Amst.*, 1:102) as his first proposal of *Conorhynchus;* that name has been proposed no fewer than five times, twice in fishes (see Neave). Bleeker proposed *Conorhynchos* as a substitute name for *Conostomus* (accredited to Duméril, 1856) because he regarded the latter as preoccupied

in birds (*Conostoma*) and in bryozoans (*Conostomum*). But, as Neave indicated, Duméril used the spelling *Conostoma*, as Hodgson had for a genus of birds (in 1842).

Subsequently, Regan (1906–08: 192) substituted *Conorhynchichthys* because *Conorhynchus* Bleeker is preoccupied by the same name in Coleoptera (*Conorhynchus* Motschoulsky, 1860). Since *Conorhynchichthys* Regan has the same type species as *Conorhynchus* Bleeker and *Conorhynchos* Bleeker, Regan's name is not available for the Middle American ariid. The South American pimelodid is still properly referred to *Conorhynchos*, but, as Gosline (1945:9, 47) indicated, on the basis of our findings, a new generic name is needed for *C. nelsoni*.

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SCRIPPS INSTITUTION OF OCEANOGRAPHY, LA JOLLA, CALIFORNIA AND MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN.

# First Records of Sinistrality in *Microstomus pacificus* (Lockington) and *Glyptocephalus zachirus* Lockington, Pleuronectid Fishes of Western North America, with Meristic Data

W. I. FOLLETT, RALPH B. MCCORMICK, AND E. A. BEST

TWO specimens of *Microstomus pacificus* (Lockington) and two specimens of *Glyptocephalus zachirus* Lockington, recently collected off northern California, represent the first records of sinistral examples of these pleuronectid species. In all Pleuronectidae except *Platichthys flesus* (Linnaeus) and *P. stellatus* (Pallas), and possibly also the New Zealand genus *Rhombosolea*, sinistrality (eyes and protective coloration on the left side) has been considered so rare as to appear teratological (Hubbs and Hubbs, 1945:236). Reversal of sides probably occurs in all species of the family, but has not heretofore been reported in either *M. pacificus* or *G. zachirus*.

Additionally, the two specimens of *G. zachirus* are the second and third known flatfish with situs inversus viscerum (which involves the reversal of the relative positions of the liver and the intestinal coils). One of these specimens is the first known flatfish in which situs inversus viscerum is not accompanied by reversal of the relative positions of the optic nerves.

## COUNTS AND MEASUREMENTS

All counts and measurements were taken as by Hubbs and Lagler (1958:19–24). Counts of all median elements were determined from radiographs. With paired elements and paired series of elements, the count of the left side (whether eyed or blind) is written to the left of the hyphen, and that of the right side, to the right of the hyphen. To show the arrangement of unbranched and branched rays in the pectoral and pelvic fins, the unbranched rays are indicated by lower-case roman numerals and the branched rays, by arabic numerals. Unbranched pectoral rays originating in front of and above the branched rays are designated anterosuperior unbranched rays; those originating behind and below the branched rays are designated posteroinferior unbranched rays.

### *Microstomus pacificus* (Lockington)

In his noteworthy contribution to the biology of *M. pacificus*, based on an examination of approximately 3,200 specimens, Hagerman (1952:14) said of this species, "The Dover sole is invariably dextral." Since that paper was written, however, two sinistral examples of this flounder have been obtained from fish markets in Humboldt County, California.

One of our specimens, a small adult female 347 mm. (S.L.) was collected by otter trawl about July 28, 1952, off northern California. The other, a small adult female (Fig. 1) 340 mm. (S.L.) was collected by otter trawl about June 6, 1957, in 70–100 fathoms, between Redding Rock (lat. 41°20′24″N., long. 124°10′42″W.) and the mouth of the Eel River Humboldt County, California. Both specimens are deposited in the California Academy of Sciences (CAS 25911 and 26368).

The meristic data for the two specimens are presented in Table I.

The dorsal-ray count (92) in the 347-mm. specimen is very low. Although Clemens and Wilby (1946:327) and Hagerman (1952:14) indicated that the dorsal-ray count in this species may be as low as 90, Townsend

FIG. 1.—Sinistral example of *Microstomus pacificus* (Lockington), CAS 26368, 340 mm. in standard length.

TABLE I

MERISTIC DATA FOR SINISTRAL EXAMPLES OF *Microstomus pacificus* AND *Glyptocephalus zachirus*[2]

Figure(s) at left of hyphen = count of left (eyed) side of specimen; figure(s) at right of hyphen = count of right (blind) side of specimen.

| | *Microstomus pacificus* | | *Glyptocephalus zachirus* | |
|---|---|---|---|---|
| | CAS 25911 | CAS 26368 | CAS 26370 | CAS 26379 |
| Standard length, mm. | 347 | 340 | 297 | 254 |
| Dorsal rays | 92 | 108 | 98 | 91 |
| Anal rays | 76 | 89 | 83 | 74 |
| Pectoral rays: | | | | |
| Unbranched and branched[1] | ii,7,i-v,2,iii | ii,7,ii-iii,5,ii | vi,5,i-iv,7 | vi,3,i-iv,6,ii |
| Total | 10-10 | 11-10 | 12-11 | 10-12 |
| Pelvic rays: | | | | |
| Unbranched and branched[1] | v,0-v,0 | v,0-v,0 | ii,3,i-ii,3,i | ii,4-ii,4 |
| Total | 5-5 | 5-5 | 6-6 | 6-6 |
| Caudal rays: | | | | |
| Principal | 9+8 | 9+8 | 9+8 | 8+8 |
| Total | 11+10 | 10+9 | 11+11 | 11+11 |
| Branchiostegals | 7-7 | 7-7 | 7-7 | 7-7 |
| Scale rows, lateral line | 151-153 | 153-155 | 134-132 | 135-129 |
| Gillrakers, first arch | 9+9-8+9 | 10+10-11+9 | 5+8-4+8 | 4+8-5+7 |
| Premaxillary teeth | 0–19 | 0–15 | 15–26 | 15–21 |
| Dentary teeth | 0–19 | 0–18 | 14–25 | 15–22 |
| Pharyngeal teeth: | | | | |
| Upper | 6+6+5-6+6+7 | 6+5+8-6+5+7 | 7+7+7-8+7+7 | 6+6+7-7+7+7 |
| Lower | 13-11 | 12-13 | 13,12-12,12 | 9,10-12,9 |
| Vertebrae, including hypural | 12+39 = 51 | 12+41 = 53 | 13+52 = 65 | 13+51 = 64 |

[1] Lower-case roman numerals = unbranched rays; arabic numerals = branched rays.
[2] All counts and measurements as by Hubbs and Lagler (1958:19–24).

(1936:20) found none with fewer than 94 dorsal rays in a series of 51 specimens, and Taylor (1957) found only three with fewer than 94 dorsal rays (one with 91, two with 88) in a series of 255 specimens.

The anal-ray count (76) in the 347-mm. specimen is exceedingly low. It is lower than any recorded by Lockington (1879a:254; 1879b:86), Norman (1934:360), Townsend (1936:18, 22), Clemens and Wilby (1946:327), or Hagerman (1952:14). Only four specimens with a lower number of anal rays have come to our attention: three specimens (of a series of 258 examined by Taylor, 1957) with an anal-ray count of 75, and a 313-mm. specimen (CAS 25910, collected off Trinidad, California) with the extremely low anal-ray count of 74.

On the eyed side, the counts of the pectoral rays are similar in the two sinistral specimens (ii,7,i and ii,7,ii). On the blind side, there is no difference in the total num-

ber of pectoral rays but there is a marked difference both in the number of branched rays and in the number of anterosuperior unbranched rays (v,2,iii and iii,5,ii). A higher total number of pectoral rays on the eyed side than on the blind side, as in the 340-mm. specimen, is normal in this species (Taylor, 1957). The higher number of branched pectoral rays on the eyed side in both specimens agrees with the observation of Hubbs and Hubbs (1945:254–7) that in pleuronectids a higher number of branched pectoral rays usually occurs on the eyed side, even in sinistral examples.

The total caudal-ray count (19) in the 340-mm. specimen is one ray lower than that in any of the 29 specimens mentioned by Townsend (1936:22).

The premaxillary and dentary teeth, which are normally restricted to the blind (left) side in this species (Lockington, 1879a:254; 1879b:86, 88), are restricted to the right (blind) side in both specimens, as would be expected in sinistral examples of this species. The counts of both the premaxillary teeth (0–19) and the dentary teeth (0–19) in the 347-mm. specimen are substantially higher than those recorded by Lockington (1879a: 254; 1879b: 86) or Norman (1934: 360). The dentary count is higher than that noted by Jordan and Evermann (1898:2655) but lower than the maximum of 20-0 recorded by Evermann and Goldsborough (1907:357) in Alaskan material. Neither the premaxillary count in the 347-mm. specimen nor the dentary count in Alaskan material, however, represents the extreme variation in this species, since a premaxillary count of 22-0 and a dentary count of 27-0 were obtained from a 412-mm. specimen (CAS 25909), collected off Point St. George, California.

The lower-pharyngeal teeth of both sinistral specimens are in a single row on each side, instead of "in two rows . . . those of the inner row larger than those of the outer, except in front, where there are a few larger teeth equal in size in both rows," as described by Lockington (1879b:86). The absence of an outer row of smaller teeth in our specimens does not appear to be significant. In other specimens that we have examined, there is much variation in the outer row. In some this row is quite as Lockington described it, but in others it consists of only one or two small teeth or is entirely absent.

The vertebral counts of both sinistral specimens fall within the variations noted by Townsend (1936:19, 22), Clothier (1951:47), and Taylor (1957). Marked abnormalities in the vertebrae of the 347-mm. specimen are revealed by a radiograph. The 10th and 11th precaudal vertebrae are fused; laterally the 1st and 2nd caudal vertebrae are somewhat disaligned (possibly by trauma); the 14th, 15th, and 16th caudal vertebrae are fused; and distally the bilateral components of the 12th, 13th, 15th, 19th, and 20th haemal spines are conspicuously separated for more than two-thirds of their length. These vertebral abnormalities are not accompanied by any anomaly of coloration, such as the piebald pattern developed by a specimen of *Platichthys stellatus rugosus* Girard in which two of the caudal vertebrae, although not fused, appeared to have been driven together (Follett, 1954:24). No vertebral abnormality is discernible in a radiograph of the 340-mm. specimen.

In both specimens the liver is on the left side of the abdominal cavity, and the intestinal coils are on the right. This arrangement of the viscera, which is characteristic of fishes in general, is almost invariably maintained in flatfishes, both normal and reversed (Hubbs and Hubbs, 1945:244).

The left optic nerve in the 340-mm. specimen crosses above the right optic nerve in the chiasma, and the two nerves are almost doubly crossed. The dorsal position of the left optic nerve in the chiasma is normal in the Pleuronectidae, even in sinistral examples (Parker, 1903:233, fig. 7; Hubbs, 1945: 13). It is probable that the left optic nerve was dorsal in the 347-mm. specimen also, but this could not be established with certainty because of the decomposition of the brain and the partial decomposition of the nerves.

### *Glyptocephalus zachirus* Lockington

Two sinistral examples of the rex sole, *G. zachirus*, have recently been collected off northern California. These appear to constitute the first definite record of reversal in this species, although a marketman who handles large numbers of this flounder at San Francisco told us that he had seen an occasional reversed individual.

One of our specimens, a small adult female 297 mm. in standard length, was taken by William H. Bartow, aboard the otter-trawler *Irene*, probably on September 12, 1958, in 87 fathoms, in the Big Flat area (lat. 40°05′N., long. 124°15′W.), west of Point Delgada, Humboldt County, California. The other, a small adult female (Fig. 2) 254 mm., (S.L.) was collected by Charles Ells, aboard the

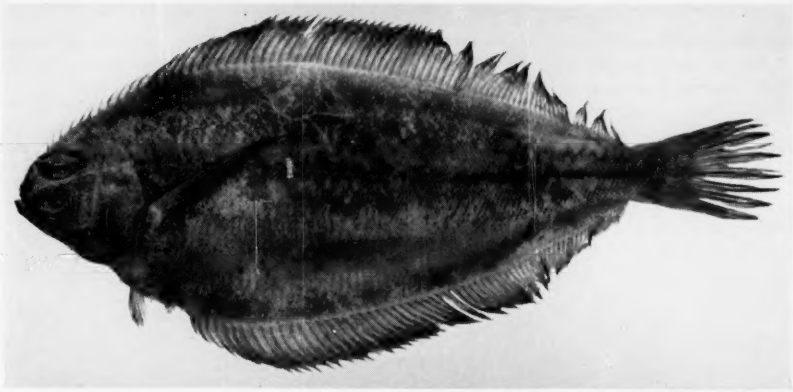

FIG. 2.—Sinistral example of *Glyptocephalus zachirus* Lockington, CAS 26379, 254 mm. in standard length, with situs inversus viscerum.

otter-trawler *Amak*, on March 14, 1959, in 72–74 fathoms, at latitude 41°40′N., longitude 124°26′W., off Crescent City, Del Norte County, California. These specimens are deposited in the California Academy of Sciences (CAS 26370 and 26379).

The meristic data for both specimens are presented in Table 1.

In the 297-mm. specimen, the ray counts of the dorsal and anal fins fall within the variation noted by Lockington (1879b:88) in the original description (the extreme dorsal-ray count of 186, later published by Lockington (1879c:43) is obviously a misprint for 106). In the 254-mm. specimen, however, the dorsal and anal counts (91 and 74) are lower than any that we have encountered in the literature.

A higher number of branched pectoral rays on the blind side than on the eyed side, as in both sinistral specimens, appears to be normal in this species. We have found that in a series of 50 dextral specimens (CAS 26654) collected off Bodega Bay, Sonoma County, California, 36 individuals have more branched pectoral rays on the left (blind) side than on the right (eyed) side, and only five individuals have more branched pectoral rays on the right side than on the left (Tables II and III). Flounders in general, however, seem to have a higher number of branched pectoral rays on the eyed side than on the blind side (Hubbs and Hubbs, 1945:257). It has been observed that the bothid species *Xystreurys liolepis* Jordan and Gilbert provides an exception to this generality (Hubbs and Marini, 1939:162). *G. zachirus* appears therefore to provide another exception. It seems significant that *X. liolepis* and *G. zachirus* differ from most other flounders in having a long falcate pectoral on the eyed side and a short rounded pectoral on the blind side. The number of branched pectoral rays (3) on the eyed side of the 254-mm. specimen is very low. This count appears only once in our series of 50 dextral specimens (Tables 2 and 4). Norman (1934:368) stated that there are four or five branched pectoral rays on the eyed side, but in our series of 50 specimens there are three to eight such rays (average 5.98). Although Lockington (1879b:89) stated that the first five rays of the pectoral fin of the eyed side are unbranched, and although we have found this to be true in 29 specimens of our series of 50, the count of six such rays in both sinistral specimens does not appear to be significant, since the first six pectoral rays on the eyed side are unbranched in 16 specimens of the series of 50 (Tables II and IV). The total number of pectoral rays (10) on the eyed side of the 254-mm. specimen is remarkably low. This count does not appear in our series of 50 dextral specimens (Table II). The total number of pectoral rays on each side in the 297-mm. specimen—11 on the blind side, 12 on the eyed side—is the third most common count in the series of 50, and appears in six specimens (Table II).

In the 254-mm. specimen, each pelvic fin has two unbranched and four branched rays (ii,4), as in the syntypes of this species (see Lockington, 1879b:88, 89). In the 297-mm. specimen, the radial count of each pelvic fin is ii,3,i. In our series of 50 dextral individ-

TABLE II

PECTORAL-RAY FORMULAE OF 50 SPECIMENS OF *Glyptocephalus zachirus* COLLECTED OFF BODEGA BAY, SONOMA COUNTY, CALIFORNIA

Lower-case roman numerals indicate unbranched rays; arabic numerals indicate branched rays.

| Blind side | Eyed side | Totals | Number of specimens |
|---|---|---|---|
| v,2,v | -vi,3,iii | 12-12 | 1 |
| vi,4,i | -vi,5,i | 11-12 | 1 |
| iii,5,ii | - v,6 | 10-11 | 1 |
| iv,5,iv | -vi,6,i | 13-13 | 1 |
| iv,6,ii | -vi,4,ii | 12-12 | 1 |
| iii,6,ii | - v,5,i | 11-11 | 1 |
| iv,6,i | -vi,5 | 11-11 | 1 |
| iv,6,ii | -vi,5,i | 12-12 | 1 |
| iv,6,iii | -vi,5,i | 13-12 | 1 |
| iv,6,iii | -vi,5,ii | 13-13 | 1 |
| iii,6,ii | - v,6 | 11-11 | 1 |
| iv,6,i | - v,6,i | 11-12 | 1 |
| iv,6,ii | -vi,6 | 12-12 | 1 |
| v,6,i | - v,6,i | 12-12 | 1 |
| v,6,ii | - v,6,ii | 13-13 | 1 |
| iv,7,i | -vi,4,i | 12-11 | 1 |
| iii,7,i | -vi,5 | 11-11 | 1 |
| iii,7,ii | - v,5,ii | 12-12 | 1 |
| iv,7,i | -vi,5,i | 12-12 | 2 |
| iii,7,i | -iv,6,i | 11-11 | 1 |
| iii,7,i | - v,6 | 11-11 | 3 |
| iii,7,i | - v,6,i | 11-12 | 1 |
| iii,7,i | -vi,6 | 11-12 | 1 |
| iii,7,ii | -iv,6,i | 12-11 | 1 |
| iii,7,ii | - v,6,i | 12-12 | 2 |
| iii,7,ii | - v,6,ii | 12-13 | 1 |
| iv,7 | - v,6 | 11-11 | 1 |
| iv,7,i | - v,6 | 12-11 | 1 |
| iv,7,i | -vi,6,i | 12-13 | 1 |
| iii,7,i | -iv,7,i | 11-12 | 1 |
| iv,7,i | - v,7 | 12-12 | 1 |
| iii,7,iii | - v,7,i | 13-13 | 1 |
| iii,7,i | -iv,8 | 11-12 | 1 |
| iii,8 | - v,6 | 11-11 | 1 |
| iii,8,i | - v,6,i | 12-12 | 1 |
| iii,8,i | -vi,6 | 12-12 | 1 |
| iii,8,i | - v,7 | 12-12 | 6 |
| iii,8,i | - v,8 | 12-13 | 1 |
| ii,9 | - v,6 | 11-11 | 1 |
| iii,9 | - v,7 | 12-12 | 1 |
| iii,9 | -iv,8 | 12-12 | 1 |

uals, 86 pelvic-ray counts of ii,4 were noted and only five counts of ii,3,i (both fins counted).

The premaxillary and dentary teeth, which

TABLE III

DIFFERENCES BETWEEN PECTORAL-RAY COUNTS OF THE TWO SIDES IN *Glyptocephalus zachirus**

Anterosuperior unbranched rays are those in front of and above the branched rays; posteroinferior unbranched rays are those behind and below the branched rays.

| | Excess of count of blind side over count of eyed side | | | | | | |
|---|---|---|---|---|---|---|---|
| | −3 | −2 | −1 | 0 | 1 | 2 | 3 |
| Branched rays | | | | | | | |
| Sinistral specimens | | | | | | 1 | 1 |
| Dextral specimens | | | 5 | 9 | 25 | 9 | 2 |
| Unbranched rays | | | | | | | |
| Anterosuperior | | | | | | | |
| Sinistral specimens | | 2 | | | | | |
| Dextral specimens | 4 | 33 | 10 | 3 | | | |
| Posteroinferior | | | | | | | |
| Sinistral specimens | | | 1 | | 1 | | |
| Dextral specimens | | | | 20 | 23 | 6 | 1 |
| Total unbranched | | | | | | | |
| Sinistral specimens | 1 | | 1 | | | | |
| Dextral specimens | 1 | 14 | 21 | 12 | 2 | | |
| Total rays | | | | | | | |
| Sinistral specimens | | | 1 | | | 1 | |
| Dextral specimens | | | 10 | 36 | 4 | | |

* Based on 52 specimens from northern California: one sinistral specimen from off Crescent City, Del Norte County, and one sinistral specimen from west of Point Delgada, Humboldt County; 50 dextral specimens from off Bodega Bay, Sonoma County.

are normally more numerous on the blind (left) side in this species (Norman, 1934:367), are more numerous on the right (blind) side in both specimens, as would be expected in sinistral examples of this species.

The vertebral counts of both specimens fall within the variation recorded by Townsend (1936:19, 22); the count of the 254-mm. specimen (13 + 51 = 64) is the same as that of one specimen mentioned by Clothier (1951:47); the count of the 297-mm. specimen (13 + 52 = 65) is the same as that noted by Jordan and Goss (1889:300), Jordan and Evermann (1898:2658), and Norman (1934: 368). Pronounced abnormalities in the vertebrae of the 254-mm. specimen appear in a radiograph. The 5th, 6th, 7th, and 8th caudal vertebrae are fused; the 19th and 20th caudal vertebrae are fused; and distally the bilateral components of the 17th, 18th, and 20th neural spines, as well as those of the 1st, 3rd, 4th, 18th, and 20th haemal spines, are conspicuously separated for more than two-thirds of their length. These vertebral abnormalities are not accompanied by any anomaly of

TABLE IV

FREQUENCY DISTRIBUTION OF RAY COUNTS OF THE PECTORAL FINS IN *Glyptocephalus zachirus*[1]

Anterosuperior unbranched rays are those in front of and above the branched rays; posteroinferior unbranched rays are those behind and below the branched rays. Numeral in parentheses indicates number of specimens.

| Formulae[2] | | Unbranched rays | | | | | | Branched rays | | Total rays | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Antero-superior | | Postero-inferior | | Total | | | | | |
| Blind side | Eyed side | Blind side | Eyed side | Blind side | Eyed side | Blind side | Eyed side | Blind side | Eyed side | Blind side | Eyed side |
| **Sinistral specimens** | | | | | | | | | | | |
| iv,6,ii (1) | vi,3,i (1) | 4(2) | 6(2) | 0(1) | 1(2) | 4(1) | 7(2) | 6(1) | 3(1) | 11(1) | 10(1) |
| iv,7 (1) | vi,5,i (1) | | | 2(1) | | 6(1) | | 7(1) | 5(1) | 12(1) | 12(1) |
| Totals | | 8 | 12 | 2 | 2 | 10 | 14 | 13 | 8 | 23 | 22 |
| **Dextral specimens** | | | | | | | | | | | |
| v,2,v (1) | vi,3,iii (1) | 2(1) | 4(5) | 0(5) | 0(25) | 2(1) | 4(2) | 2(1) | 3(1) | 10(1) | 11(15) |
| vi,4,i (1) | vi,4,i (1) | 3(30) | 5(29) | 1(28) | 1(19) | 3(3) | 5(21) | 4(1) | 4(2) | 11(17) | 12(28) |
| iii,5,ii (1) | vi,4,ii (1) | 4(15) | 6(16) | 2(12) | 2(5) | 4(19) | 6(13) | 5(2) | 5(10) | 12(27) | 13(7) |
| iv,5,iv (1) | v,5,i (1) | 5(3) | | 3(3) | 3(1) | 5(16) | 7(11) | 6(11) | 6(24) | 13(5) | |
| iii,6,ii (2) | v,5,ii (1) | 6(1) | | 4(1) | | 6(5) | 8(2) | 7(22) | 7(10) | | |
| iv,6,i (2) | vi,5 (2) | | | 5(1) | | 7(4) | 9(1) | 8(10) | 8(3) | | |
| iv,6,ii (3) | vi,5,i (5) | | | | | 8(1) | | 9(3) | | | |
| iv,6,iii (2) | vi,5,ii (1) | | | | | 10(1) | | | | | |
| v,6,i (1) | iv,6,i (2) | | | | | | | | | | |
| v,6,ii (1) | v,6 (9) | | | | | | | | | | |
| iii,7,i (9) | v,6,i (6) | | | | | | | | | | |
| iii,7,ii (5) | v,6,ii (2) | | | | | | | | | | |
| iii,7,iii (1) | vi,6 (3) | | | | | | | | | | |
| iv,7 (1) | vi,6,i (2) | | | | | | | | | | |
| iv,7,i (6) | iv,7,i (1) | | | | | | | | | | |
| iii,8 (1) | v,7 (8) | | | | | | | | | | |
| iii,8,i (9) | v,7,i (1) | | | | | | | | | | |
| ii,9 (1) | iv,8 (2) | | | | | | | | | | |
| iii,9 (2) | v,8 (1) | | | | | | | | | | |
| Totals | | 173 | 261 | 70 | 32 | 243 | 293 | 343 | 299 | 586 | 592 |

[1] Based on 52 specimens from northern California: one sinistral specimen from off Crescent City, Del Norte County, and one sinistral specimen from west of Point Delgada, Humboldt County; 50 dextral specimens from off Bodega Bay, Sonoma County.
[2] Lower-case roman numerals indicate unbranched rays; arabic numerals indicate branched rays.

coloration (cf. Follett, 1954:24). No vertebral abnormality appears in a radiograph of the 297-mm. specimen.

The most remarkable abnormality that we have observed in these specimens is the condition known as situs inversus viscerum—the reversal of the characteristic asymmetrical arrangement of the viscera. Such reversal appears to have been observed in only one other flatfish—the one known sinistral specimen of the Japanese pleuronectid *Tanakius kitaharae* (Jordan and Starks), recorded by Hubbs and Hubbs (1944:245). Ordinarily, in flatfishes the liver is on the left side of the abdominal cavity, and the intestinal coils are on the right—even in individuals with the eyes and protective coloration on the side that is normally blind (Cunningham and MacMunn, 1894:801). In the present specimens the liver is on the right, rather than on the left; and the intestinal coils are on the left, rather than on the right. Furthermore, the intestine projects into the backward extension of the coelom on the left side,

rather than on the right. The possibility that reversal of the normal arrangement of the viscera might be less rare in *G. zachirus* than in other flatfishes is seemingly dispelled by the fact that among 701 dextral examples of this species (619 in the San Francisco market and 82 in the collection of the California Academy of Sciences) we encountered no specimen with situs inversus viscerum.

The relative positions of the optic nerves in the chiasma of the 297-mm. specimen could not be determined, because of the decomposition of the nerves and brain. In the 254-mm. specimen, the left optic nerve crosses above the right optic nerve in the chiasma, and the two nerves are almost doubly crossed. As this arrangement of the nerves is normal in the Pleuronectidae, this specimen (unlike the sinistral example of *T. kitaharae*) is not completely reversed. It is the first known flatfish in which situs inversus viscerum is not accompanied by reversal of the relative positions of the optic nerves.

## Summary

Two specimens of *Microstomus pacificus* (Lockington) and two specimens of *Glyptocephalus zachirus* Lockington, collected off northern California, represent the first records of sinistral examples of those species of Pleuronectidae. In that family of flatfishes, sinistrality (eyes and protective coloration on the left side), except in a few species, has been considered so rare as to appear teratological.

Neither specimen of *M. pacificus* exhibits extreme meristic counts. One, however, has an unusually low number of dorsal and anal rays and a high number of premaxillary and dentary teeth. Vertebral abnormalities occur in the specimen with low radial counts but not in the other specimen. The vertebral abnormalities are not accompanied by any anomaly of coloration, such as the piebald pattern in a specimen of *Platichthys stellatus rugosus* Girard in which two vertebrae appeared to have been driven together. In both sinistral specimens the normal arrangement of the viscera is retained, with the liver on the left and the intestinal coils on the right. In one specimen, and probably in both, the relative positions of the optic nerves are normal for reversed pleuronectids—with the left nerve crossing above the right in the chiasma, and the two nerves almost doubly crossed.

One specimen of *G. zachirus* exhibits no significant meristic or vertebral abnormalities. The other, which has unusually low dorsal- and anal-ray counts, shows pronounced vertebral abnormalities, which are not accompanied by any anomaly of coloration. Both specimens have a higher number of branched pectoral rays on the blind side than on the eyed side. This differential, the opposite of that in most flounders, appears to be normal in *G. zachirus*—as it has been observed to be in the bothid species *Xystreurys liolepis* Jordan and Gilbert (which also has a long falcate pectoral on the eyed side and a short rounded pectoral on the blind side). Both sinistral specimens have six unbranched pectoral rays on the eyed side. In a series of 50 dextral individuals, 16 have six unbranched pectoral rays on the eyed side, and 29 have five such rays. One sinistral specimen has two unbranched and four branched pelvic rays (ii,4) on each side; the other, ii,3,i on each side. In the series of 50 dextral individuals, a pelvic-ray count of ii,4 was noted 86 times and a count of ii,3,i only five times (both fins counted). The most remarkable abnormality in the sinistral specimens is reversal of the characteristic arrangement of the viscera: The liver is on the right; the intestinal coils are on the left; and the intestine projects into the backward extension of the coelom on the left side. This condition (situs inversus viscerum), which has been recorded in only one other flatfish—the one known sinistral specimen of the Japanese pleuronectid *Tanakius kitaharae* (Jordan and Starks)—was not encountered among 701 dextral examples of *G. zachirus*. In one sinistral specimen, the relative positions of the optic nerves in the chiasma could not be determined. In the other, the left optic nerve crosses above the right optic nerve in the chiasma, and the two nerves are almost doubly crossed. This is the first known flatfish in which situs inversus viscerum is not accompanied by reversal of the relative positions of the optic nerves.

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California Academy of Sciences, San Francisco, California; California Department of Fish and Game, Eureka, California; and California Department of Fish and Game, Stanford, California.

# Postlarval Development and Diet of the Largescale Sucker, *Catostomus macrocheilus*, in Idaho[1]

Craig Macphee

In young suckers a series of morphological, physiological, and behavioral changes occur after the absorption of the yolk sac. Such larval phenomena have been studied extensively in other species of fish. Balinsky (1948) defined 46 stages in the development of minnows from the unfertilized egg to the acquisition of scales and the completion of the lateral-line canal. Le Cren (1951) found that two straight logarithmic regression lines were

[1] Contribution of the Idaho Cooperative Wildlife Research Unit; College of Forestry, University of Idaho; the Idaho Fish and Game Department; the Wildlife Management Institute, and the U. S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, cooperating.

needed to describe suitably the length-weight relationship of the yellow perch, *Perca flavescens* (Mitchill), one for larval fish 6 to 30 mm. in fork length and one for larger fish. Stewart (1926) described developmental characteristics of the postlarval white sucker, *Catostomus commersoni* (Lacépède), and related changes in the position of the mouth from terminal to inferior with changes in feeding behavior. In addition to describing and contrasting the development and diet in postlarval and early juvenile stages of the largescale sucker, *Catostomus macrocheilus* Girard, this paper integrates some of the concepts developed by Balinsky, Le Cren and Stewart within a single species.

*Materials and Methods.*—Between June 28 and September 9, 1957, ten samples of young suckers were collected near redds created on or about June 22 by numerous spawning adults. The redds were located in the North Fork of the Payette River, about halfway between Cascade Reservoir and Payette Lake, Idaho. Information on largescale sucker spawning habits and temperatures for this stream are given by Keating (1958).

The weights of the fish were measured by means of an analytical balance and fork lengths by projecting their images on a screen and correcting for magnification. The writer is indebted to Mr. Osborne E. Casey, Idaho Department of Fish and Game, for his assistance in making field collections and in weighing and measuring the fish used in this study.

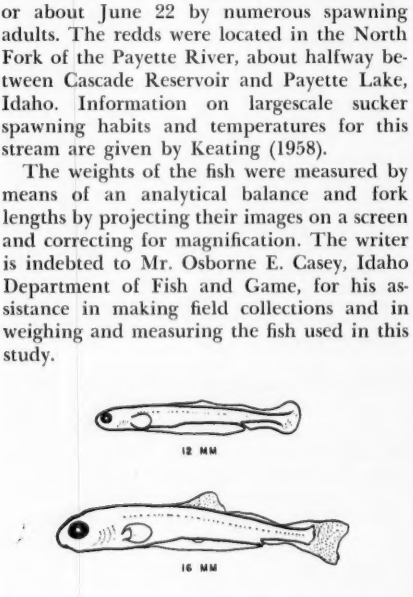


FIG. 1.—Four stages in the development of the largescale sucker, *Catostomus macrocheilus*.

Stomach contents of fish were counted in a Sedgewick-Rafter counting chamber. Total counts were made in most cases, but whenever a particular organism was abundant, totals were estimated by counting only a fraction of them.

*Postlarval Development.*—The morphology of postlarval fish has been investigated by many authors. Typically a median, pellucid fin fold (Fig. 1) is present which almost completely encircles the trunk and tail.

As indicated in Table I which lists the sequence of developmental events in postlarval and juvenile suckers, the anal-caudal, dorsal-caudal and pre-anal segments of the fin fold disappear in this order. The dorsal-caudal segment is present in largescale suckers about 18 mm. long. In contrast, Stewart (1926) stated that in white suckers, 9 mm. in length, the dorsal fin is well defined, the remainder of the dorsal median fin fold having disappeared.

In a specimen 8 mm. long the posterior vertebral column is quite straight and the caudal fin is diphycercal in shape. According to Norman (1947) such a tail is found in almost all larval or embryonic fishes. For a brief period, the caudal fin of the sucker is fundamentally heterocercal in that the caudal fin rays first appear ventral to the notochord, the tip of which turns dorsally with development. In suckers 15 mm. long, two hypural plates are outlined and the caudal fin is distinctly homocercal. As a result of differential growth, the rounded tail of early postlarvae changes to a double emarginate one before becoming forked. For the white sucker, Stewart (1926) reported that the two lobes of the caudal fin show at 12 mm. whereas they appear in largescale suckers about 14 mm. in average length.

Dorsal and anal fin lobes develop from thickened portions of the fin fold. An examination of the fin lobes in which rays were just developing indicated that the first few rays appear almost simultaneously, additional rays being added one at a time as the fish grows.

Quantitative relationships between the number of fin rays and body length are indicated in Fig. 2. Fish with no rays in the dorsal and anal fins are omitted from the graphs. Because the numbers of rays in the fins reach an upper limit, a curve of the type $R = A - Be^{-kL}$, which is asymptotic in character, was used to describe the distribution of points. A graphic method similar to that used by Brody (1945) was adopted for evaluating the constants. In this exponential equation,

TABLE I

DEVELOPMENTAL CHANGES IN THE POSTLARVAL LARGESCALE SUCKER, *Catostomus macrocheilus*

| Structure | Number of specimens in transition range | Minimum length, mm. | | Maximum length, mm. | | Mid-point of transition range |
|---|---|---|---|---|---|---|
| | | At which structure developed | At which structure disappeared | At which structure was not developed | At which structure disappeared | |
| Rounded tail | 23 | | 13.1 | | 15.2 | 14.15 |
| Double emarginate tail | 35 | 13.1 | | | 15.2 | 14.15 |
| Dorsal fin lobe | 30 | 13.1 | | 15.2 | | 14.15 |
| Forked tail | 25 | 14.0 | | 15.2 | | 14.6 |
| Dorsal fin rays | 30 | 14.0 | | 15.2 | | 14.6 |
| Pelvic fin buds | 23 | 14.3 | | 15.2 | | 14.75 |
| Anal fin lobe | 23 | 14.3 | | 15.2 | | 14.8 |
| Straight gut | 24 | | 14.6 | | 16.0 | 15.3 |
| Anal fin rays | 33 | 14.3 | | 16.5 | | 15.4 |
| Anal-caudal fin fold | 21 | | 15.1 | | 17.3 | 16.2 |
| Pelvic fin rays | 12 | 16.0 | | 17.4 | | 16.7 |
| Dorsal-caudal fin fold | 27 | | 16.0 | | 19.5 | 17.75 |
| S-shaped gut | 26 | 14.6 | | | 23.5 | 19.05 |
| Pre-anal fin fold | 6 | | 19.1 | | 20.7 | 19.9 |
| Coiled gut | 3 | 23.2 | | 23.5 | | 23.35 |

$R$ equals the number of fin rays; $A$ represents the maximum number of rays possible; and $B$ is a frequency parameter denoting an artificial value for the number of fin rays present when the size of the fish is extrapolated to zero length. The letter $k$ stands for the instantaneous relative increase in length with respect to the maximum increase in rays to be made and the size class of developing fish is indicated by the letter $L$. The formula of the curve for the dorsal fin (76 fish) is $R = 13.3 - 4440e^{-0.440L}$ and that for the anal fin (57 fish) is $R = 8.8 - 108e^{-0.204L}$. A comparison of the two curves show that the number of rays commence to increase at an accelerated rate in the dorsal fins in contrast to those in the anal fins, the value of the asymptote for the dorsal being greater than that for the anal fin.

Of the paired appendages, the pectoral fins were already well developed in a postlarval sucker 8 mm. long. Pelvic fin buds begin to appear on white suckers, 15 mm. long, and on largescale suckers of about the same size.

In fish up to about 13 mm. long, in anterior view, the mouth has an inverted U-shaped outline, the tip of the jaws being about level with the middle of the eyes. As the fish grows, the jaws rotate from an inclined plane to a horizontal one so that the forward edge of the lower jaw which initially was almost below, eventually lies posterior to that of the upper jaw, the lower jaw lying within the curvature of the upper one. In fish 13 to 16 mm. long, the lower lip gradually changes from an inferior to a posterior position with reference to that of the upper lip. Thus, the upper lip remains in a terminal position longer than that of the lower one and in fish up to about 16 mm. in length the mouth might morphologically still be

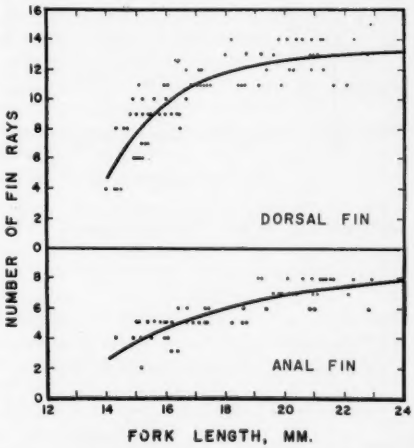


FIG. 2.—The relationship between body length and number of fin rays in the postlarval development of the largescale sucker, *Catostomus macrocheilus*.

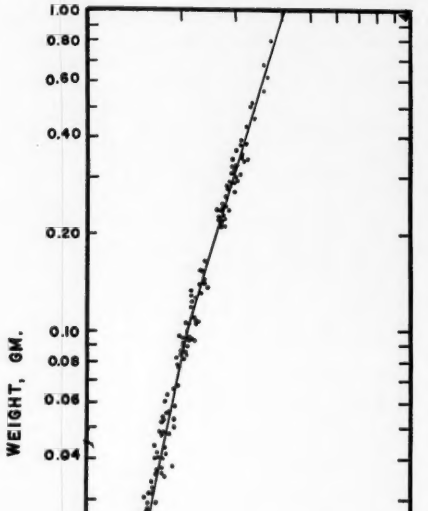


FIG. 3.—The length-weight relationship of 189 postlarval and juvenile largescale suckers, *Catostomus macrocheilus*.

TABLE II

COMPARISON OF THE PERCENTAGE OCCURRENCE OF VARIOUS FOOD ITEMS IN THREE LENGTH CLASSES OF THE LARGESCALE SUCKER

*Catostomus macrocheilus*

| Food item | Fork length, in mm. | | |
|---|---|---|---|
| | 12.0–15.9 (55)* | 16.0–23.5 (57) | 23.6–38.0 (42) |
| Diatoms | 29 | 60 | 90 |
| Filamentous alga | 0 | 0 | 10 |
| Protozoans | 13 | 35 | 69 |
| Rotifers | 71 | 82 | 69 |
| Cladocerans | 65 | 73 | 60 |
| Midges | 18 | 32 | 19 |
| No Organisms | 13 | 0 | 0 |
| Detritus | 0 | 0 | 17 |
| Sand | 0 | 2 | 26 |

* The number of specimens is given in parentheses.

considered terminal although functionally inferior in position. By the time the young sucker is about 19 mm. long, the upper jaw has migrated below the level of the lower margin of the eyes and is definitely inferior in position.

*Length-Weight Relationship.*—In most fishes where length-weight relationships have been studied, the postlarval stage of development has been omitted. In Fig. 3, a logarithmic graph illustrates the length-weight relationship of 189 young suckers. The relationship cannot be described adequately by a single straight line, for an inspection of the graph reveals that when the young fish attain a length of about 20 mm., a point of inflection occurs due to a change in growth rate. The formula, $\log W = (7.48295 - 10) + 4.9125 \log L$, describes the regression line of 113 suckers 12 to 20 mm. long, and the formula, $\log W = (7.95531 - 10) + 3.3496 \log L$, describes that of 76 suckers 20 to 38 mm. long. Fish smaller than 20 mm. increase in weight at a faster rate than those larger than 20 mm. in length.

The point of inflection is significant in that it marks not only the position of change in the growth form but also the end of all major physiognomic changes that have taken place during metamorphosis. For these two reasons, the point of inflection as determined by the point of intersection of the two regression lines can be used, at least in this species, as a relatively precise indicator of the upper limit of the postlarval stage of development.

*Diet.*—In order to analyze dietary change in postlarval and juvenile suckers, three length classes (Table II) which corresponded to three phases in the development of the digestive tract were chosen; namely, from a straight tube through an S-shaped state to a coiled tube. Both postlarval and juvenile fish are represented in the intermediate class.

All food items were counted in the straight digestive tract which was about 50 percent of the length of the fish. For the two larger length classes, the posterior limit of the stomach was arbitrarily delineated by severing the tract at the middle of the first reverse bend. The relative length of the gut examined was about 25 percent of the fork length for suckers 16 to 21 mm. and 29 percent for suckers 25 mm. long.

Only seven out of 154 suckers had empty digestive tracts. Because of their small size (12.9 to 15.3 mm.), they are associated with the "top-feeding" period described by Stewart (1926) in which the postlarval white sucker commenced to feed. The arithmetic

mean and standard error of the relative condition coefficient (Le Cren, 1951) for these seven non-feeding fish were $0.90 \pm 0.06$ which indicates that although these non-feeding fish were thinner than the feeding ones they were not significantly so for the small sample tested.

An inspection of Table II reveals that the percentage occurrence of diatoms and protozoans increased progressively as the gut developed from a straight tube to a coiled one. The percentage occurrence of rotifers, cladocerans and midges, however, was greatest in the intermediate length class. A comparison of these data with those presented by Carl (1936) for immature largescale suckers from Shuswap Lake and largescale suckers from Eagle River, British Columbia, reveals several marked differences. In fish from Shuswap Lake, the percentage occurrence of cladocerans and midge larvae was greater than, and that of diatoms, far smaller than that found for fish from Payette River. In fish from Eagle River, no cladocerans were reported. In the Payette fish, neither ostrocods, copepods, stone fly larvae, water mites, nor terrestrial insects were found. In contrast, protozoans and especially rotifers were common. The numbers of midge larvae found in any one sucker were relatively few and consequently little significance can be attached to changes in their relative occurrence. Such qualitative differences in diet could reflect seasonal, geographical, and environmental variations in the species composition of available food organisms.

Sand grains were present in one fry, 22.4 mm. in length. In the largest length class, 11 fry, 26.7 mm. in average length, also contained sand grains and seven fry, 31.5 mm. in average length, contained detritus. The presence of sand and detritus in the stomachs of the fry suggests a change from a discriminate to an indiscriminate type of feeding behavior. It is noteworthy that such indiscriminate feeding followed the development of the coiled digestive tract, the added length of which is possibly better adapted for assimilating detritus.

In 154 fish, seven, one and five suckers in the shortest, intermediate and longest length classes contained an average of 13,000, 22,000, and 16,000 diatoms, the next highest count for one fish in each class being 127, 2,550, and 4,010 diatoms respectively. One 36 mm. sucker had eaten about 420 rotifers and 490 cladocerans. Such values marked the extreme tail ends of frequency distributions which were "Poisson-like" in shape because most fish ate little or none of any one particular food type and relatively few fish ate a lot of a single species of organism.

A comparison of the average number of food items for the 14 fish which ate the most extreme quantities of diatoms and invertebrates detailed above with the average per fish in Table III indicates that, in general, the majority of young suckers ate small quan-

TABLE III

A COMPARISON OF THE AVERAGE NUMBERS OF FOOD ITEMS EATEN PER FISH AND PER GRAM WEIGHT OF FISH IN THREE LENGTH CLASSES OF LARGESCALE SUCKERS, *Catostomus macrocheilus*

| Food item | Size range, mm. | Number of fish | Average number of items per fish | Average weight of fish, gm. | Average number of items per gram weight of fish |
|---|---|---|---|---|---|
| Diatoms | 12.0–15.9 | 48 | 8.6 | 0.017 | 506 |
| | 16.0–23.5 | 56 | 246 | 0.086 | 2860 |
| | 23.6–38.0 | 37 | 573 | 0.330 | 1740 |
| Protozoans | 12.0–15.9 | 55 | 0.3 | 0.018 | 17 |
| | 16.0–23.5 | 57 | 3.7 | 0.085 | 44 |
| | 23.6–38.0 | 42 | 17.2 | 0.334 | 51 |
| Rotifers | 12.0–15.9 | 55 | 25.7 | 0.018 | 1430 |
| | 16.0–23.5 | 57 | 25.5 | 0.085 | 300 |
| | 23.6–38.0 | 41 | 22.2 | 0.325 | 68 |
| Cladocerans | 12.0–15.9 | 55 | 4.9 | 0.018 | 272 |
| | 16.0–23.5 | 57 | 11.7 | 0.085 | 138 |
| | 23.6–38.0 | 41 | 11.5 | 0.325 | 35 |

tities of food. The 14 fish are omitted from the table since the inclusion of these few would distort the average of the majority. Fish in the smallest length class ate a relatively low proportion of diatoms and protozoans and a high proportion of rotifers and cladocerans, especially on a per weight basis. Differences in size of the digestive tube sampled make absolute comparisons of stomach contents difficult and such variations should be borne in mind when interpreting the data.

The "top-feeding" behavior of fish in the smallest length class accounts for the high utilization of cladocerans as well as the low utilization of diatoms and protozoans in the diet. About 18 per cent of the fish under 16.0 mm. contained cladocerans (*Bosmina* sp.) with clear, thin carapaces typical of pelagic forms. Their presence helps to substantiate field observations in which young suckers were observed near the surface of the water presumably feeding. Many suckers in this smallest class had eaten diatoms, bottom-dwelling protozoans and cladocerans with the dark, thick carapaces associated with bottom forms. This indicates that at least some of this group were already feeding on or near the bottom.

*Discussion.*—Although many phases in the development and food habits of the largescale sucker rather closely parallel those of the white sucker, *Catostomus commersoni*, the extension of knowledge to other localities and to other species is important in order to form certain generalizations for suckers as a whole. Such details of postlarval development as eye size, position and shape of intestine, C-shaped caudal fin and characteristics of the median fin fold are shown in a photograph of a humpback sucker by Douglas (1952). A comparison of this photograph with the smallest of the largescale suckers in Fig. 1 shows no marked morphological differences. Minor differences in development between the white sucker and the coarsescale sucker have already been mentioned. That an even closer resemblance exists among larvae than among adults of different sucker species, emphasizes the closeness of the phylogeny of the sucker family.

The white sucker described by Stewart (1926) is more developed for its size than the largescale sucker. This statement is substantiated by the early disappearance of the dorsal median fin fold, and the early definition of the dorsal fin and lobed tail.

Except for one individual 8 mm. in length, all suckers collected were 12 mm. or larger and had reached at least Stage 35 in the developmental scale outlined by Balinsky (1948). Stage 35 is characterized by having 7 to 9 caudal rays, the fin fold deepening at the sites of the future dorsal and anal fin rays, and the posterior end of the notochord bent upward. Based on major physiognomic characteristics, Stage 43, characterized by the complete absence of the median fin fold, represents the beginning of the juvenile stage and Stage 42, which still contains a posterior remnant of the pre-anal fin fold, represents the last of the postlarval stages of development. This contrasts with the suggestion of Winn and Miller (1954) that for minnows and suckers in general, the postlarval or feeding larva period should be considered to terminate at Stage 40. On the other hand, Le Cren differentiated between larval and juvenile perch by means of length-weight regression lines but did not indicate whether or not their point of intersection coincided with the termination of larval metamorphosis. In the largescale sucker, the point of intersection of the postlarval and juvenile regression lines at the 20 mm. point serves to separate Stage 42 and 43 as well as to mark a point of divergence in body form.

Not only must young suckers respond to food but they must also adapt their feeding behavior to correspond with modifications in body structures. Because these modifications are most pronounced in early life, any correlations which might exist between state of development and feeding habits are likely to be most marked in postlarval fish.

While the change in behavior pattern from a "top feeding" to a "bottom feeding" one is abrupt, yet morphological adaptations are necessarily gradual. This alteration in behavior is more closely associated with the posterior shift of the lower jaw, while the upper lip is still terminal, than with the migration of both jaws from a terminal to an inferior position. Stomach analysis show that this shift in the lower jaw does not prevent the postlarval sucker from selecting particulate food items such as cladocerans. Adaptation of the jaws for ventral feeding, however, does precede the lengthening of the digestive tract. Although a general rise in diatom consumption was associated with a change in position of the jaws and an increase in length of the intestine, indiscriminate feeding on detritus was not associated with the position of the jaws but rather, with the development of the coiled intestine.

*Summary and Conclusions.*—Except for

the coiling of the intestine in the largescale sucker, *Catostomus macrocheilus*, larval metamorphosis is complete in postlarvae about 20 mm. in fork length.

The length-weight relationships of postlarval and juvenile suckers are described by two straight logarithmic regression lines. The intersection of these lines coincides with the end of major changes in physiognomy and thus, could be useful as a criterion for designating the end of postlarval development.

Percentage frequency of occurrence for diatoms and protozoans was significantly higher in juvenile than in postlarval fish while that for rotifers and cladocerans was relatively uniform.

In general, the average number of diatoms and protozoans ingested per gram weight of fish was greater for juvenile than for postlarval suckers whereas the average number of rotifers and cladocerans eaten was considerably less for juvenile than for postlarval suckers.

A change in behavior from surface to bottom feeding is associated with a shift in the lower jaw of the mouth, whereas a behavioral change from discriminate to non-discriminate feeding is associated with the development of the coiled intestine.

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Fishery Management, College of Forestry, University of Idaho, Moscow, Idaho.

# On the Swim Bladder and its Posterior Communication with the Exterior in an Indian Clupeoid Fish, *Ilisha indica*

Padmakar V. Dehadrai

THE swim bladder of certain clupeoids has been reported to possess in addition to the pneumatic duct an opening to the exterior at the posterior end, near the anus. This opening is thought by some to be a safety valve, but in fact little is known of its structure or function.

During the course of investigations on the swim bladder of teleostean fishes, the swim bladders of clupeoid genera commonly found in India (*Sardinella, Thrissocles, Ilisha* and *Pellona*) were observed to possess a well-developed posterior mechanism communicating with the exterior. The present paper is an attempt to elucidate the aspects of this complex modification in *Ilisha indica* (Swainson).

### Historical Resumé

Weber (1820) described a communication with the exterior from the posterior end of the swim bladder of *Clupea harengus* through a duct opening into the genital pore between the genital duct and the ureter aperture. Huxley (1881) confirmed the presence of the posterior communication of the swim bladder of *C. harengus* with the exterior. Ridewood (1892) described the presence of this peculiar modification in the swim bladders of *C. harengus, C.* [= *Sardina*] *pilchardus, C.* [= *Alosa*] *alosa* and *Engraulis enchrasicholus.* Later, de Beaufort (1909) mentioned a direct communication of the swim bladder to the exterior through an aperture situated close

to the anus in *C. harengus, C, sprattus, Sardina pilchardus* and *Pellona elongata.* He also dealt with the development of this modification in the herring and suggested the probable function of a safety valve. Svetovidov (1952) referred to this peculiar feature of the swim bladder in certain commercial clupeoids and remarked that it had not yet been investigated to a sufficient degree. Most recently O'Connell (1955) described a postanal opening in *Sardinops caerulea* and suggested that it might be an escape mechanism for excess gas during rapid ascents.

The abundant clupeoid fauna of Indian waters has encouraged the study of this modification. *I. indica* is a marine member of the family Clupeidae, order Isospondyli. It is widely distributed in the Indo-Pacific Ocean and is pelagic in habit. The study of the posterior extension of its swim bladder has revealed many interesting points which are reported here.

## Gross Anatomy of the Swim Bladder

The swim bladder of *I. indica* is a simple, sac-like structure with shining walls. It lies obliquely in the abdominal cavity as in other clupeoid fishes having a more or less laterally compressed body. The swim bladder is physostomous having a long, slender pneumatic duct communicating with the pyloric end of the stomach by means of an opening guarded by a sphincter (Fig. 1). Anteriorly the swim bladder tapers gradually and ends in the form of a small, club-like structure having a pair of dorso-laterally disposed processes (Fig. 1). These processes become firmly attached to the vertebral column. At its anterior-most end the swim bladder gives off a median precoelomic diverticulum which divides into two "air ducts". The author has observed that these air ducts enter the cartilaginous tubes of their respective sides to proceed forwards and upwards towards the exoccipital bone and establish a relationship with the ear.

The posterior portion of the swim bladder of *I. indica* descends posteriorly as a tubular structure which eventually opens to the exterior near the vent, behind the serial openings of the rectum, gonadal duct and urinary bladder respectively (Fig. 1). The urinary bladder lies behind the swim bladder within the abdominal cavity but its narrow posterior neck crosses the descending tube of the swim bladder and comes to lie in front of it. These posterior extremities of the various ducts are bound together to form a compact complex.

The wall of the swim bladder consists of a tunica externa and a tunica interna which are easily separated from one another. The tunica externa is glistening white. On removal of this tough outer coat the modifications of the tunica interna are noticed. Anteriorly it is thin and transparent but it increases in thickness as one proceeds posteriorly. At the posterior end of the swim blad-

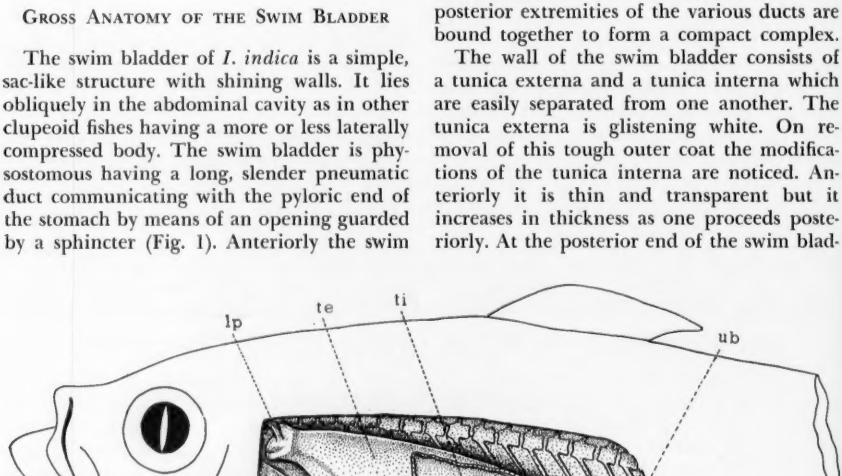


Fig. 1.—Lateral view of the swim bladder of *Ilisha indica* and its posterior communication with the exterior in association with other visceral organs. List of abbreviations for all figures: *cm.*—circular muscle layer; *dp.*—pneumatic duct; *ep.*—epithelium; *fet.*—fibro-elastic tissue; *g.*—gonad; *gd.*—gonadal duct; *lm.*—longitudinal muscle layer; *lp.*—lateral process; *pmap.*—posterior muscular appendage; *r.*—rectum; *sb.*—swim bladder; *te.*—tunica externa; *ti.*—tunica interna; and *ub.*—urinary bladder.

der the tunica interna develops a number of concentric rings. Where the swim bladder descends posteriorly the tunica interna is modified to form a thick, muscular vermiform appendage (Fig. 1). The lumen of the swim bladder proper communicates with that of the appendage by means of a large, oval opening, the margin of which shows a thickened ridge. In a fixed specimen this muscular appendage is observed to be a short curved structure lying free in the descending portion of the tunica externa. Moreover, in this shrunken condition, it does not reach to the end of the covering tube of tunica externa but extends only about half its length. The external surface of the muscular appendage has irregular ridges and furrows which give it a rough and wrinkled appearance.

### Histological Findings

Histological investigations were made of the swim bladder wall, the muscular appendage and the common region of the various duct openings. The peculiar nature and interrelationships of these openings and other interesting features are reported.

*The swim bladder wall.*—The details of the tunica interna histology are considered alone. It consists of four layers as follows (Fig. 2): 1. the outermost layer of loose fibroelastic tissue; 2. a circular layer of unstriated muscle fibers; 3. a considerably thickened layer of longitudinal muscle fibers which is thrown into prominent folds at many places; and 4. a layer of inner epithelium.

*The posterior muscular appendage.*—This appendage is made up of the same layers and tissues as the tunica interna of the swim bladder wall and is different only in the disposition, thickness and differentiation of the muscle layers. At the beginning of the appendage the thickness of the circular muscle layer is the same as in the swim bladder wall (Fig. 3). This layer increases in thickness towards the external opening (Fig. 4). In addition, the circular muscle layer is disposed into deep convolutions corresponding to the outer wrinkled markings of the appendage.

The longitudinal layer of muscle fibers, on the contrary, has its maximum thickness at the beginning of the posterior appendage where the muscles are seen to be arranged into large lobes projecting into the lumen of the appendage (Fig. 3). As the appendage proceeds towards its inferior opening the longitudinal layer of muscle fibers becomes

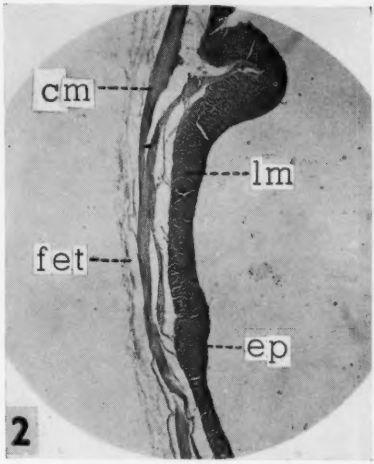


Fig. 2.—Transverse section through the tunica interna of the swim bladder wall of *I. indica* showing the inner folds. × 100.

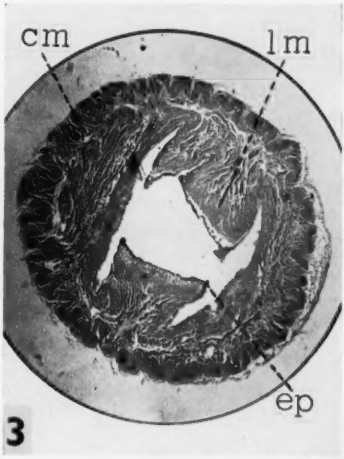


Fig. 3.—Transverse section of the posterior muscular appendage of *I. indica* through its upper or proximal portion showing the four large lobes of the longitudinal layer of muscle fibers. × 60.

thin and the whole of the inner surface is thrown into a number of long, slender villiform processes (Fig. 4). Most of these villiform processes become smaller at the distal ends after giving off secondary branches. The lumen of the appendage is lined with columnar epithelium.

FIG. 4.—Transverse section of the posterior muscular appendage of *I. indica* through its lower or distal portion near the terminal opening. The inner wall is broken into a number of villiform processes. × 60.

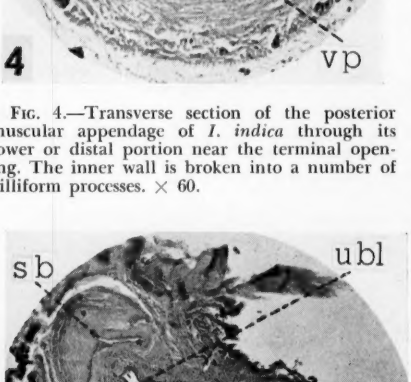


FIG. 5.—Transverse section through the terminal portions of the rectum, gonadal duct, urinary bladder and swim bladder of *I. indica* near the vent showing the independent openings. × 60.

*The rectum, gonadal duct, urinary bladder and swim bladder in the region of the vent.*—Serial horizontal sections of the posterior portion of the vent region clearly show that all the tubes maintain separate identity and open independently (Fig. 5). They are guarded by separate sphincters and all four tubes at their terminal portions are bound together by soft connective tissue.

## DISCUSSION

The histological study of the swim bladder wall of *Ilisha indica* indicates that the longitudinal muscle fiber layer is peculiarly thickened. Moreover, it is disposed into deep folds at intervals. The significance of this is not clear.

In many clupeoid fishes the swim bladder has been reported to communicate with the exterior by means of a ventral tube-like structure arising from its posterior end. This tube is reported to open to the exterior beside the genital aperture. Varying observations by workers such as Weber (1820), Huxley (1881), Ridewood (1892), and de Beaufort (1909) lead to no definite conclusions as to its precise location or structure. Even the presence of this modification in *Clupea* [= *Alosa*] *alosa* as reported by Ridewood (1892) was denied to exist by de Beaufort (1909). The present author has found that this modification as reported by Ridewood (1892) and de Beaufort (1909) in the case of *Pellona* actually becomes completely atrophied. O'Connell (1955) gives a resumé of the limited literature concerning the relationships of the openings in the vent region and also the possible functions of the posterior extension of the swim bladder in clupeoids.

Weber (1820) was able to fill the swim bladder with mercury or air and then express them from the posterior opening of *Clupea harengus*. Huxley (1881) suggested that the mouse-like squeaks made by captured herring might be caused by the escape of gas through this posterior opening of the swim bladder but de Beaufort (1909) remarks that he never saw gas escaping from this opening of the herring kept in the Amsterdam Aquarium.

Aside from Maier & Scheuring (1923) with *Clupea harengus* and O'Connell (1955) with *Sardinops caerulea* the literature concerning the anatomical and histological structure of this region is not described in detail. The study of the swim bladder in *I. indica* shows the tunica interna to be involved to a great degree in the formation of the posterior opening mechanism and thus may well control the actual manipulation of the volume of air in the swim bladder. The particular formation of the thick, vermiform appendage in *I. indica* has also been observed by the author in fishes of the genera *Sardinella* and *Thrissocles*.

The structure of the tunica externa of the posterior extension of the swim bladder suggests that it is merely a protective covering. The free condition of the muscular appendage within the tunica externa supported only by the loose fibro-elastic tissue layer probably facilitates its movements during functioning. The inversely proportional thickness of the circular and longitudinal muscle layers to each other in the appendage is very characteristic and may be presumed to be a feature conducive to effective functioning.

The anatomy and histology of the posterior muscular appendage indicate that it probably serves as an efficient exhaust control mechanism under complex reflex control. On the basis of our knowledge of the innervation of the swim bladder, two types of nerve fibers, excitatory and inhibitory, may be presumed to take part in its function (Fänge, 1953). The inhibitory function on the swim bladder of the vagus has been confirmed by Kuiper (1915) and Plattner (1914), Jones and Marshall (1953), etc. The muscular tonus in the swim bladder is said to be maintained by stimuli from the sympathetic system, Franz (1937), Jones and Marshall (1953). Thus, considering these facts, a feasible series of actions during the working of this mechanism can be surmised. The excitatory fibers probably bring about the retraction upwards of the appendage away from the external opening by virtue of the contraction of the longitudinal muscle fibers. A close approximation of the large lobes in the lumen of the appendage might also occur at the same time. The contraction of the greatly developed circular muscle layer near the distal end of the appendage would result in a close approximation of the villiform processes in this region and cause a maximum congestion of the region. All of these actions would be conducive to a more or less complete closure of the posterior appendage and thus prevent the passage of air to the exterior from the swim bladder.

The inhibitory fibers would probably cause a relaxation of these muscle layers which would result in the widening of the lumen of the appendage. The widely open end of the appendage would then reach to the main exit and facilitate the expulsion of air to the exterior.

A safety valve function may thus be attributed to this posterior opening of the swim bladder through the action of its muscular appendage. The occurrence of this unique feature among marine clupeoids is noteworthy. Experimental studies on living specimens is necessary, however, to confirm this explanation regarding its function.

Maier and Scheuring (1923) described the anus, urinary opening and posterior opening of the swim bladder in the herring as being surrounded by a common sphincter muscle. O'Connell (1955) showed the openings in the Pacific sardine to be separate, with only the genital and urinary openings having a common sphincter. He felt that the sphincter of Maier and Scheuring was in reality the "protractor analii" muscle. Like O'Connell, the author feels that a common sphincter would not appear to have any physiological value since each duct performs different functions. In *I. indica* there is no sphincter muscle in common but rather these openings are held together firmly by connective tissue.

## Summary

The peculiar features in the structure of the swim bladder in *Ilisha indica* (Swainson) have been described in detail.

The muscularis mucosa of the tunica interna of the swim bladder wall is disposed into deep folds whose function is obscure.

The morphological study of the posterior communication of the swim bladder to the exterior in *I. indica* helps towards an understanding of its probable function. On the basis of these evidences it is felt that this posterior communication serves as an efficient exhaust control mechanism under complex nervous reflexes and thus confirming the function as a safety valve attributed to it by various workers.

The anus, gonadal duct, urinary bladder and swim bladder all have separate openings in the vent region. Although they are held together by connective tissue this study shows that they do not have a common muscular sphincter as sometimes held.

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DEPARTMENT OF ZOOLOGY, UNIVERSITY OF DELHI, DELHI 8, INDIA

# The Morphological Relationships of the Lateral-Line Nerve in Certain "Electric Fishes"

EDWARD M. NELSON

SINCE ancient times the special adaptation of certain fishes to produce strong electrical shocks has intrigued humans, both the scientific and the curious (Amberson, 1958). In the eighteenth and nineteenth centuries much work was done to determine the source, means of production and the magnitude of this electrical discharge. In recent years the basic unit of the electric organ, the electroplate, has become an experimental tool for the study of biological electricity.

The emphasis of research in the past has been upon the electric organ, particularly that of fishes producing strong shocks. Recently it has been discovered that many more fishes possess electric organs of a much lesser degree which, instead of producing shocks, establish a rhythmically pulsating field about themselves (Keynes, 1957). One fish, the "electric eel", possesses both types of electric organs.

Apparently because of this concentration on the electric organ the remainder of the anatomy of these fishes has been generally passed over, the lateral-line nerve being one such structure. This paper represents a morphological study of the lateral-line nerve as it is found in the teleost fishes possessing electric organs. Postulations of the significance of the various locations in which the lateral-line nerve is found are also made. Table I lists the specimens of electric fishes used in this study. Numerous teleosts were also examined but not listed.

## THE LATERAL-LINE NERVE IN A GENERAL TELEOST

A system of sensory organs (of the neuromast type) forming pits and/or canals over the head and body is to be found in nearly every teleost fish. This system is referred to as the lateral-line system and various functions have been attributed to it. That portion of the system associated with the head is innervated by a branch of the VIIth cranial (facial) nerve and is called the anterior lateral nerve. That portion associated with the trunk and tail of the fish is innervated by a branch of the Xth cranial (vagus) nerve, called the posterior lateral nerve. It is this latter nerve with which this study is concerned.

In teleost fishes as a group the vagus nerve arises from the medulla oblongata of the hind brain and passes posteriorly to exit the skull through a foramen in the posterior or postero-lateral aspect of the cranium. The lateral-line nerve (the posterior lateral branch of the vagus) may be given off while the vagus nerve is still within the cranium or shortly

after it has emerged from the cranium. This nerve then curves postero-laterally over the lateral surface of the anterior body-wall musculature in the fascial plane between the body-wall musculature and the musculature of the pectoral girdle. Posterior to the pectoral girdle the lateral-line nerve runs the length of the body of the fish embedded in the superficial, "red," portion of the lateral body-wall musculature along the lateral or outer border of the horizontal myoseptum.

At intervals the lateral-line nerve gives off fine branches to the sense organs of the lateral-line. Occasionally there may be secondary branches of the lateral-line nerve, particularly in the initial portion in the pectoral girdle region.

### *Astroscopus* (*Fig. 4*)

*Astroscopus*, the "stargazer" of the Atlantic and Mediterranean coasts, is a very interesting electric fish (Dahlgren and Silvester, 1901). Here the lateral-line nerve presents the same morphological relationships seen in the general teleost. The nerve passes along the length of the body lying in the most superficial edge of the horizontal myoseptum.

The electric organ of *Astroscopus* fills the orbit, being the modified extra-ocular muscles of the eye. This fish is of the shocking type of electric fish.

### *Malapterurus* (*Fig. 3*)

In *Malapterurus*, the "electric catfish" of Africa, the lateral-line nerve also has the same morphological relationships as seen in the general teleost. The vagus nerve leaves the postero-inferior aspect of the cranium and immediately gives off the lateral-line nerve. This nerve then turns laterally along the ossified Baudelot's ligament (the "transscapular bone") to appear on the lateral surface of the body-wall musculature. The lateral-line nerve then passes caudally along the length of the body at the outer margin of the horizontal myoseptum.

An additional nerve, the "dorsal nerve", is to be found in *Malapterurus*. This "dorsal" or "recurrent" nerve is a branch of the VIIth cranial nerve and leaves the posterior aspect of the cranium at its upper medial region. The dorsal nerve then proceeds along the length of the body to the adipose fin. It is situated alongside of the medial septum of the back and lies in the fascial plane between the dorsal longitudinal muscle bundle and the superior lateral body-wall muscle mass. Along its course the dorsal nerve gives off fine branches which pass postero-laterally to the skin.

The electric organs of *Malapterurus* form a subcutaneous sheet about the body from either side. This sheet is closely adherent to the skin and is separated from the lateral body-wall musculature by a fascial plane of an abundant loose connective tissue. The body-wall musculature in addition is covered with a layer of fatty tissue. *Malapterurus*

TABLE I

LIST OF SPECIMENS OF ELECTRIC FISHES USED IN THE STUDY OF THE MORPHOLOGICAL RELATIONSHIPS OF THE LATERAL-LINE NERVE

MORMYRIDAE:
1. *Mormyrus caballus* (AMNH 6665)
" " (AMNH 6665)
3. *Mormyrus kannume* (MCZ 32533)
4. " " (MCZ 32533)
5. *Hyperopisus bebe* (MCZ 26428)

GYMNOTIDAE:
1. *Sternopygus macrurus* (CNHM 50191)
2. " " (CNHM 32787)
3. " " (CNHM 54491)
4. *Eigenmannia virescens* (CNHM 10252)
5. " " (CNHM 56800)
6. " " (CNHM 54494)
7. *Hypomus artedi* (CNHM 50189)

ELECTROPHORIDAE:
1. *Electrophorus electricus* (CNHM 31719)
2. " " (CNHM 18012)
3. " " (Brookfield Zoo)
4. " " (CNHM)

URANOSCOPIDAE:
1. *Astroscopus y-graecum* (CNHM 54753)

MALAPTERURIDAE:
1. *Malapterurus electricus* (CNHM 16864)
2. " " (CNHM)
3. " " (CNHM)

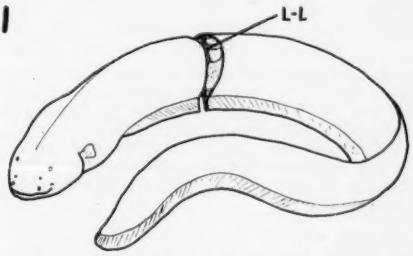


FIG. 1.—*Electrophorus electricus*. The lateral-line nerve (L-L) is located in the angle between the inner margin of the horizontal myoseptum and the vertebral column. In this fish the nerve is in addition surrounded by a fatty tissue sheath.

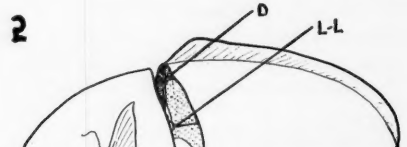


FIG. 2.—*Mormyrus kannume*. The lateral-line nerve (L-L) is located in the angle between the inner margin of the horizontal myoseptum and the vertebral column. The "dorsal nerve" (D) is located adjacent to the medial dorsal septum in the fascial plane between the dorsal longitudinal muscle bundle and the superior lateral body-wall muscle mass.

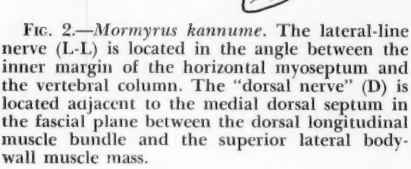


FIG. 3.—*Malapterurus electricus*. The lateral-line nerve (L-L) is located at the outer margin of the horizontal myoseptum in the superficial body-wall musculature. The "dorsal nerve" (D) is located adjacent to the medial dorsal septum in the fascial plane between the dorsal longitudinal bundle and the superior lateral body-wall muscle mass.

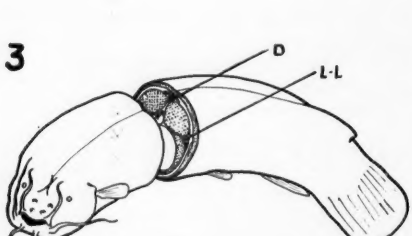


FIG. 4.—*Astroscopus y-graecum*. The lateral-line nerve (L-L) is located at the outer margin of the horizontal myoseptum.

is another of the shocking type of electric fishes.

### GYMNOTIDS AND *Electrophorus* (*Fig. 1*)

In the gymnotid fishes the relationships of the lateral-line nerve are very different from that of the general teleost. In this situation the nerve emerges from the postero-lateral aspect of the cranium associated with the opercular muscles and passes superficial to the pectoral girdle and the Weberian apparatus (formed by the first four vertebrae). Thereafter, however, the nerve penetrates the body-wall musculature and follows the horizontal myoseptum to its medial attachments along the vertebral column. The lateral-line nerve then passes along the length of the body situated in this deep position giving off its lateral branches along the way.

The electric organs of the gymnotids are small elongated structures in the caudal region of the fishes. These organs are of the pulsating field-producing type.

*Electrophorus*, the electric eel, is a specialized offshoot of the gymnotid stock. Its lateral-line nerve has the morphological relationships found in the gymnotid fishs. One difference, however, is the grossly apparent sheath of fatty tissue which surrounds the nerve as it lies in the junction between the horizontal myoseptum and the vertebral column. John Hunter in 1775 mentioned and figured the lateral-line nerve of *Electrophorus* but did not appreciate its significance beyond referring to it as the "singular nerve" (Hunter, 1775).

The electric organs of *Electrophorus* occupy the greater portion of the total mass of the fish. There are three pairs of organs of which the Main Organ and the Organ of Hunter are of the shock-producing type while the Organ of Sachs is of the pulsating field-producing type.

### MORMYRIDS (*Fig. 2*)

The gymnotids, including *Electrophorus*, as a group are limited to the fresh-waters of South America. The mormyrid fishes form a group which is strikingly parallel to the gymnotids but are limited to the fresh-waters of Africa (Lissmann, 1958). In the mormyrids the lateral-line nerve is deeply situated at the very beginning. It continues in this deep position passing along the length of the body in the angle between the horizontal myoseptum and the vertebral column. It gives off

its lateral branches to the sense organs segmentally.

The lateral-line nerve in the mormyrids gives off a substantial branch from its dorsal aspect immediately after leaving the cranium. This branch passes dorsally and at the junction of the pectoral girdle with the skull it emerges from beneath the post-temporal bone to become superficial on the dorsal body-wall musculature. This "dorsal nerve" then enters the fascial plane between the dorsal longitudinal muscle bundle and the superior lateral body-wall muscle mass where it is situated against the medial septum of the back. In this position it passes caudally into the region of the dorsal fin. Along the way the dorsal nerve gives off segmental branches which pass postero-laterally to the skin.

The electric organs of the mormyrids consist of two pairs located in the caudal region. The majority of these fishes have the pulsating field-producing type of activity.

### Probable Significance of the Morphological Relationships of the Lateral-Line Nerve

It appears very probable that the two different patterns of morphological relationships of the lateral-line nerve should have a significant functional *raison d'etre*. In those electric fishes which are of the purely shocking type, such as *Malapterurus* and *Astroscopus,* the lateral-line nerve retains the usual teleost pattern having the nerve passing the length of the body situated in the superficial lateral body-wall musculature. During discharge of the electric organs the nerve may well be subjected to self-stimulation. In the case of *Astroscopus,* however, the electric organs are far anterior while the body is usually almost completely buried in the sand. In *Malapterurus* the loose connective tissue and the fatty layer intervene between the electric organs and the nerve. In both cases even if the lateral-line nerve were to be self-stimulated during a discharge it would only be occasionally and of little ecological consequence.

In the purely pulsating field-producing type of electric fishes, such as the gymnotids and the mormyrids, the discharge of the electric organs would produce a more-or-less continuous condition of self-stimulation for the lateral-line nerve. In this situation the lateral-line system would become useless unless some sort of special modification were developed. This modification appears to be to "bury" the nerve deeply within the body!

In the case of *Electrophorus* the electrical activity produced is of both types. Here the lateral-line nerve is not only buried deeply within the body but in addition it is surrounded by a sheath of insulating fatty tissue.

### The Dorsal Nerve

Among the fishes studied here the mormyrids and *Malapterurus* have been shown to possess a dorsal nerve. As far as morphological relationships are concerned this nerve appears to be identical in the two forms. That of the mormyrids however is a branch of the lateral-line nerve whereas that of *Malapterurus* is a branch of the VIIth cranial nerve.

Wright (1958) has suggested that the dorsal nerve of the mormyrids is the receptor of the pulsating electrical activity of these fishes. The gymnotids, also of the pulsating field-producing type, have no such nerve. The electrical receptor system or mechanism for the object-finding or direction-finding functions suggested for the pulsating field has yet to be clearly ascertained.

The dorsal nerve of *Malapterurus* finds its homologue in the recurrent nerve of most other siluroids. In siluroids generally this dorsal nerve is believed to be associated with the great number of integumentary taste buds on the backs of these fishes.

*Acknowledgments.*—I am grateful for the aid given me by the various institutions indicated in Table I: AMNH—American Museum of Natural History; CNHM—Chicago Natural History Museum; MCZ—Museum of Comparative Zoology of Harvard University, and the Brookfield Zoo at Brookfield, Illinois. Through the cooperation of these institutions and their personnel this work was made possible and completed while I was a member of the Department of Anatomy, Stritch School of Medicine, Chicago.

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DEPARTMENT OF ANATOMY, SCHOOL OF MEDICINE, UNIVERSITY OF PUERTO RICO, SAN JUAN 22, PUERTO RICO

# *Astronesthes nigroides*, a New Species of Stomiatoid Fish from the Eastern Pacific Ocean[1]

ROBERT H. GIBBS, JR. AND WILLIAM ARON

INCLUDED in the collections made by the M. V. BROWN BEAR in the eastern North Pacific during the University of Washington, Department of Oceanography's 1958 International Geophysical Year program is a new species of *Astronesthes* (Family Astronesthidae). The species was taken in a modified version of the Isaacs-Kidd midwater trawl (Aron, 1959) and is the first of its genus to be reported from the eastern Pacific.

### *Astronesthes nigroides sp. nov.*

*Holotype.*—USNM 179754; collected July 18, 1958 at 38°55.7′N, 137°44.6′W, at a depth of 225 meters. Standard length 77.8 mm. This is the only known specimen.

*Comparative Diagnosis.*—A species of *Astronesthes* with the anal origin directly below the end of the dorsal base; a barbel that is slightly shorter than the head and which has the terminal third slightly swollen; luminous material covering most of the operculum other than the preopercle; 14 dorsal rays; 15 anal rays; 10 IP photophores which bend outward only slightly at the pectoral base; 17 PV; 19 VAV; 15 OV; 20 VAL; and 13 AC photophores.

In barbel structure, *A. nigroides* resembles only *A. niger*. In the presence of luminous material on the operculum, it resembles only *A. cyaneus*. In twelve meristic characters used here, it is within the range or no more than one integer away from the recorded extreme of nine characters for both *A. niger* and *A. cyaneus*. *A. richardsoni* (= *A. filifer*) and *A. splendidus* agree in as many characters, but the entire facies of these two species is different, the former having, among other differences, no terminal modification of the barbel, the latter a bulb with several small distal filaments. *A. nigroides* is compared with these four species in Table I.

*Description.*—Depth of body nearly 6 in standard length; caudal peduncle depth less than one-third of greatest body depth. Head 4.4 in standard length. Bony orbit 3.6 in head length, equal to snout. Upper jaw about five-sixths of head length. Premaxilla with two long, barbed fangs anteriorly, the second longest, and three groups of two small teeth; maxilla with 19 contiguous, pointed teeth, slanting backward, in a comblike series. Mandible with a tiny anterior tooth, followed by a large, barbed fang and then five groups of two or three small teeth, with a few tiny teeth between and lateral to them. A tooth on each side of vomer. Palatine teeth in a long row of 8–10 longer anterior teeth, 5–7 shorter posterior teeth. Three sets of basibranchial teeth, each consisting of two teeth on each side of the head of a bone. Pharyngobranchial teeth in two prominent patches. Gill teeth of anterior arch in pairs, 5 upper pairs, 14 lower. A median patch of luminous tissue between nostrils. Operculum except for preopercle covered with luminous material. Branchiostegal rays 18. Barbel slightly shorter than head length, the axis of stem pigmented nearly to distal end, the terminal one-third swollen and containing luminous material.

Dorsal fin with 14 rays, its origin behind pelvic insertion; difference between predorsal and prepelvic lengths 6.4 per cent of standard length. A small dorsal adipose fin between dorsal and caudal fins, a small patch of luminous material under its free posterior end. Anal fin with 15 rays, its origin directly below end of dorsal base. A small ventral adipose fin present a short distance before anus.

[1] Contribution number 234 from the Department of Oceanography, University of Washington. This work was supported in part by the Office of Naval Research, Contract 477 (10) and in part by the National Science Foundation.

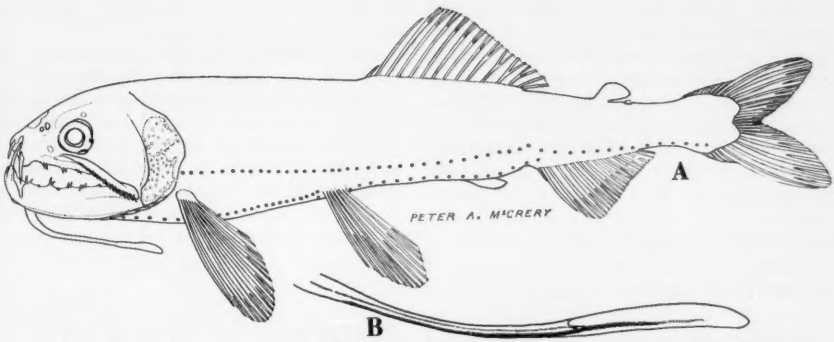


FIG. 1.—*Astronesthes nigroides:* A. left lateral view of the holotype, drawn by Peter A. McCrery; and B. enlarged view of the left lateral view of the barbel, drawn by R. H. Gibbs, Jr.

TABLE I

DIFFERENTIAL CHARACTERS OF FIVE SPECIES OF *Astronesthes*

| | *A. nigroides* (1) | *A. niger* (24) | *A. cyaneus* (4) | *A. richardsoni* (8) | *A. splendidus* (1) |
|---|---|---|---|---|---|
| Barbel structure | terminal ⅓ swollen | terminal ⅙–⅓ swollen | same size throughout | same size throughout | bulb with filaments |
| Luminous material on opercle | present, extensive | absent | present, extensive | absent | absent |
| Ventral series of photophores with sharp angle at pectoral base | no | yes | yes | no | no |
| Palatine teeth | 15–20 | 10–15 | 2–5 | 1–4 | 7–11 |
| Maxillary teeth | 19 | 11–17 | 16–20 | 11–16 | 15 |
| Dorsal rays | 14 | 15–17 | 18–20 | 13–14 | 11–14 |
| Anal rays | 15 | 12–15 | 12–15 | 14–18 | 18 |
| IP | 10 | 8–9 | 9–10 | 10–11 | 10–11 |
| PV | 17 | 12–15 | 15–17 | 15–17 | 16–17 |
| VAV | 19 | 18–21 | 17–19 | 20–21 | 20 |
| OV | 15 | 12–14 | 12–14 | 14–15 | 16 |
| VAL | 20 | 19–22 | 17–19 | 20–22 | 18–21 |
| AC | 13 | 10–12 | 11 | 11–12 | 11–12 |
| Pectoral rays | 8 | 7–9 | 8 | 7–8 | 8 |
| Pelvic rays | 7 | 7 | 7 | 7 | 7 |

Pectoral rays 8; pelvic rays 7. All fin rays lined with inconspicuous luminous material.

Ventral row of photophores continuous, not sharply angulate at base of pectorals. AC continuous, not broken into levels. Photophore counts: IP 10; PV 17; VAV 19; OV 15; VAL 20; AC 13. Small photophores on most of head and body, most dense ventrally, tending to form oblique rows along myotome boundaries; a double midventral row present. Pectoral and pelvic fins with photophores along the rays.

Color dark brownish-black, darkest ventrally. Fins unpigmented except for photophores on pectoral and pelvic, and narrow, light crossbands on caudal. Head between nostrils and most of operculum with white luminous material.

Measurements (all in millimeters): standard length 77.8; snout to dorsal origin 42.6; dorsal origin to caudal base 34.6; snout to anal origin 59.7; snout to pelvic origin 37.6; head length 17.6; barbel length 16.0, swollen tip 5.1; bony orbit length 4.9; snout length 4.9; upper jaw length 14.7; greatest body depth 13.0; least caudal peduncle depth 3.5.

Caught in the same haul with the new species were a number of other new or rare species including: a new melamphaeid in the genus *Melamphaes;* the first records of *Melanostomias biseriatus* (Gibbs, ms.) and *Photonectes margarita* from the Pacific Ocean; the larval stage of the unusual argentinoid *Bathylychnops exilis* (Cohen, ms.); and the pelagic apogonid *Rhectogramma sherbourni.* The occurrence of these species can be related to the oceanographic data taken during the cruise (Fleming, 1959). At the point of capture of the new species a band of Central water from the south interleafs between the deeper Intermediate water and the surficial halocline water. Considering the generally subtropical and tropical distribution of the genus *Astronesthes,* this points to the probability of further captures of the new species south of the latitude of the type locality. It is also probable that captures made further to the south will be made at greater depths.

*Etymology.*—The name *nigroides* is an adjective of comparison, alluding to the similarity to *Astronesthes niger.*

*Acknowledgments.*—The authors are indebted to Dr. Maurice Rattray, Department of Oceanography, University of Washington, for his cooperation during the cruise on which the species was captured, and for his assistance in interpreting the oceanographic results, and also to Dr. Arthur Welander, College of Fisheries, University of Washington, for critically reviewing the manuscript.

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Department of Biology, Boston University, Boston, Mass. and Department of Oceanography, University of Washington, Seattle, Wash.

## Ichthyological Notes

A NEW GEOGRAPHIC RECORD FOR THE AMERICAN BROOK LAMPREY, *LAMPETRA LAMOTTEI.*—A single adult male *Lampetra lamottei* was captured in fall, 1955, in a seine haul made in the Oyster River, Strafford County, near Durham, New Hampshire. The identification of this specimen was kindly confirmed by Dr. Reeve M. Bailey, Curator of Fishes, Museum of Zoology, University of Michigan. Subsequent attempts to find more adults in the same area failed. However, during December, 1958, a bait-dealer discovered some ammocetes when he was re-setting a minnow-holding box in a small stream tributary to the Oyster River. Upon examination, these larvae proved to be immature *L. lamottei* as described by Vladykov (*Le Naturaliste Canadien, Quebec. 77(3–4):73–95,* 1950). The collections described here record for the first time the presence of this species in southeastern New Hampshire, between its previously known occurrence in Connecticut and in Quebec.

Adult *L. lamottei* were discovered constructing their nests on May 8, 1959, in Wednesday Brook, the stream in which the larvae were found. Redd construction and spawning behavior were similar to those described by Dean and Sumner (*Trans. N. Y. Acad. Sci. 16:321–24,* 1898) and Young and Cole (*Amer. Nat. 34:617–20,* 1900). Seven adults were collected. The total lengths (in mm.) and weights (in gm.) of four females and nine males taken on May 10, 1959, are as follows: (a) females —110 mm., 2.3 gm.; 110, 2.8; 120, 3.0; and 120, 3.5; (b) males—106 mm., 2.3 gm.; 107, 2.5; 110, 2.8; 113, 2.7; 117, 2.5; 117, 2.8; 120, 3.8; 121, 3.2; and 132, 4.1. A specimen that escaped capture was seen on May 13, 1959. No more were seen during subsequent observations, and by May 18, 1959, strands of filamentous algae were beginning to grow on some of the earlier spawning sites. Apparently I had discovered them at the end of their breeding period. My identification of these specimens was corroborated by Dr. V. D. Vladykov, Department of Biology, University of Ottawa.

Wednesday Brook arises in Lee, runs for about 1¼ miles, and then empties into the Oyster River, still in Lee, N. H. Measurements of the stream taken July 8, 1959, showed the flow to be 360 gallons per minute. The volume of flow at that date was about one-third less than when the lamprey larvae were collected. Average width was determined visually. In the collecting area, most of the stream was five to six feet in width with an occasional pool widening to 10 to 12 feet. Water temperature measurements taken during

the period of observations varied between 50° F and 60° F. The highest temperature was caused by a heavy, warm rainstorm which increased the stream volume to about double its normal flow. The water temperature dropped rapidly as the water level fell after the storm, and at the last observation date (May 18) it was 50° F again. On July 8, 1959, the temperature was still 50° F. This stream is described on page 59 of the Biological Survey of the Androscoggin, Saco and Coastal Watersheds, Survey Rept. 2, N. H. Fish and Game Department, Concord, 1937. It was designated as tributary study station No. 22 of the Oyster River in the Coastal Watershed.

The range of this species of lamprey as described in Hubbs and Lagler (*Cranbrook Inst. Sci. Bull. 26:28*, 1947) and in Moore (In *Vertebrates of the United States*, Blair et al. *McGraw-Hill Co., p. 44*, 1957.) does not include New Hampshire. In fact, Connecticut is the only New England State in which the species has been recorded. Vladykov (*Quebec Dept. Fish. Contrib. 26:7–67*, 1949.) wrote that it was present in the Province of Quebec. He stated that it was typically confined to small, cold brooks near the source of rivers tributary to the St. Lawrence River. The fishes associated with the lampreys in those streams were *Cottus cognatus* and *Salvelinus fontinalis*. The description applies well to Wednesday Brook except that *Cottus cognatus* is missing.

The adults were collected by carefully placing a D-shaped dip net close to the downstream edge of the spawning bed. When lampreys tired because of their strenuous activities, they periodically drifted downstream a short distance, which of course brought them into the net. Attempts to capture the lampreys by sweeping the net across the redds were fruitless. When disturbed in this manner, the lampreys usually darted sideways and disappeared into dense beds of *Nasturtium officinale* that were present. In some instances, they escaped by burrowing rapidly into the substratum along the edges of the stream.—PHILIP J. SAWYER, *Department of Zoology, University of New Hampshire, Durham, New Hampshire,*

NOTES ON THE BIOLOGY OF THE BUTTERFLY RAYS, *GYMNURA ALTAVELA* AND *GYMNURA MICRURA*.—Information about the genus *Gymnura* van Hasselt 1823 in the western Atlantic has been summarized by Bigelow and Schroeder (*Sears Found. Mar. Res. 1 (2):396–416*, 1953.). It is evident that much of the information about the biology of the species comprising this genus is fragmentary. The present paper adds further observations, especially those pertaining to reproduction.

*Gymnura altavela* (Linnaeus), 1758.—Forty-six individuals were examined from Delaware Bay otter trawl collections made in water 15 to 35 feet deep and having salinities of 24 to 30 ‰. The rays were taken during the periods July 4 to September 5, 1956, July 5 to August 27, 1957, July 30, 1958, and July 22 to August 19, 1959. Another 13 were collected by otter trawl aboard the U. S. Fish & Wildlife Service M/V *Delaware* in 27 fathoms of water off the North Carolina coast from February 24 to 26, 1958. Twenty-five of the total 59 animals were females.

A disk width-weight relationship for both sexes was calculated from 19 of the Delaware Bay fish, with the two derived constants being $\log C = -3.45$ and $n = 2.97$ in the formula $W = CL^n$, where $W$ = weight in pounds and $L$ = disk width in inches.

None of the 14 females collected from Delaware Bay during the summer of 1956 were pregnant. The left ovaries were developed but in a quiescent condition. (The right gonad is undeveloped in both sexes.) The ovarian eggs were small although filled with some yolk. One 53-inch female contained seven eggs with a size range of 7 to 16 mm., a 57-inch ray had nine eggs ranging from 10 to 12 mm. and a third female, 69½ inches, contained 11 eggs varying from 10 to 12 mm.

One 72-inch female, weighing 113 pounds, taken on July 30, 1958, contained six ovarian eggs 25 to 30 mm. in diameter.

The five females collected during February, 1958 and three of the five taken in July–August, 1959 were pregnant; either carrying in the uteri newly deposited eggs or well developed embryos. Four of the six females carrying eggs had one egg case in each uterus. The numbers of eggs in each egg case varied (Table 1).

The eggs were each approximately 30 mm. in diameter. They were juxtaposed in the cases and when preserved in this position, they were often distorted but generally assumed an elliptical shape approximately 25 × 35 mm. The cases were transparent and amber colored. The ends of the cases were attenuated, much thickened, and somewhat twisted, but with no regular spiraling. The cases were compressed, with a ridge on each side.

The uterine villi of the two females carrying young were of uniform size and distribution. The uterine fluid was watery with a whitish cast to it. The embryos had the general conformity of the adult. The tail spines were sheathed. The yolk-sac was almost completely absorbed; about the same condition and size regardless of embryo dimension. The young show the effect of crowding within the uteri; the larger the number of young in each uterus and the total carried by the parent, the smaller the size per individual embryo (Table 1).

Eight of the specimens collected in 1958 were

TABLE 1

OBSERVATIONS ON VARIOUS PREGNANT *Gymnura altavela*.

| Disk width of female in inches | Egg Number in uteri | | Embryos in uteri | | | | Sex | |
|---|---|---|---|---|---|---|---|---|
| | | | Number | | Disk width (mm.) | | | |
| | Right | Left | Right | Left | Right | Left | Right | Left |
| North Carolina Waters—1958 | | | | | | | | |
| 61 | 2 | 3 | — | — | — | — | — | — |
| 71 | 2 | 4 | — | — | — | — | — | — |
| 73 | — | — | 3 | 1 | 362<br>365<br>371 | 413 | 3 ♂ | 1 ♂ |
| 79 | 3 | 4 | — | — | — | — | — | — |
| 80 | — | — | 4 | 3 | 197<br>238<br>248<br>254 | 263<br>282<br>292 | 4 ♀ | 1 ♂, 2 ♀ |
| Delaware Bay—1959 | | | | | | | | |
| 63½ | 4 | — | — | — | — | — | — | — |
| 68½ | * | 5 | — | — | — | — | — | — |
| 78 | — | 6 | — | — | — | — | — | — |

* one case, no eggs.

TABLE 2

OBSERVATIONS ON *Gymnura micrura* FEMALES FROM DELAWARE AND CHINCOTEAGUE BAYS

| Disk width in inches | Ovarian eggs | | Number of embryos |
|---|---|---|---|
| | Number | Size | |
| 23⅞ | No evidence of development | | — |
| 26¾ | — | 11–12 mm. | — |
| 32⅛ | 5 | 16 mm. | 5 |
| 34 | — | — | 5 |
| 34¼ | 5 | 16 mm. | 5 |
| 35½ | 6 | 16 mm. | 5 |

males ranging in size from 21 to 49 inches and appeared to be immature. The males collected during the summers of 1956 and 1957 varied from 40 to 55 inches. They possessed enlarged left testes and when these were cut a milky fluid was released, indicating that these summer-caught males were sexually mature.

Some estimate of size at sexual maturity for the females and the period of gestation can be inferred. The summer-caught females from Delaware Bay in 1956, ranging in size from 47 to 69 inches, were non-pregnant and contained small, yolked ovarian eggs. Those females taken from Delaware waters in the summers of 1958 and 1959, ranging from 63½ to 78 inches, and those caught in North Carolina in February, 1958, ranging from 61 to 80 inches, were pregnant, or in the case of the one 1958 specimen contained large ovarian eggs presumed ready for ovulation. This would suggest that females attain sexual maturity with a disk breadth of at least 61 inches and a calculated weight of 70 pounds.

Coles (*Proc. Biol. Soc. Wash. 28:93,* 1915.) reported an 82 inch female with four embryos taken on May 22, 1914 from North Carolina waters. The presence of well developed embryos occurring in February, and in May (Coles, *ibid.*) indicate that parturition occurs in late winter and in early summer. The presence during mid-summer and mid-winter of shell-encased eggs in the uteri, showing no embryonic development, suggests the initiation of two gestation periods each year for this species. Whether there are two such periods during the year for each female or a prolonged period of reproductive activity for the species is still open to question. The authors tend to prefer the former notion.

A freshly caught 15 cm. (S.L.) spot, *Leiostomus xanthurus,* was recorded from the stomach of one *G. altavela.* The lens from the eyes of two squid or fish were taken from a second ray, while a third contained the vertebral column of a bony fish, lower jaw of a small shark and the eye lens from a squid or fish. The remaining 22 stomachs examined were empty.

*Gymnura micrura* (Bloch and Schneider), 1801. —Five adult females were collected from areas in

Delaware Bay where the salinity ranged from 24 to 30 ‰ and depths up to 25 feet, and one from Chincoteague Bay, Maryland, during the periods September 9, 1955, August 27 to September 12, 1956, and June 20 to August 2, 1957. One 242 mm. (disk width) free swimming young was collecteed from Delaware Bay on September 17, 1952.

The eggs that were next to be released from the ovaries (left ovary in all cases) of the above adults can be identified (Table 2). Based on egg development in these various specimens and observations made by Gudger (*Proc. Biol. Soc. Wash. 26:100*, 1913) regarding size at maturity, the 26¾ inch ray taken on August 2, 1957 was probably becoming sexually mature.

The dimensions and sex of the embryos carried by the pregnant rays are recorded in Table 3. The 16 mm. embryos taken from the female on June 20, 1957 were free in the uterus as evidenced by the piece of egg case that escaped with the uterine fluid when the uterus was cut open. The larger embryos of the other females were wrapped around each other and their digestive tracts filled with the uterine secretion as described by Wood-Mason and Alcock (*Proc. Roy. Soc. London 50:203*, 1891). There was some question about certain of the trophonemata being hypertrophied and extending into the spiracles of the embryos.

Based on the size of the free living 242 mm. ray taken in September, 1952, the intra-uterine young recorded in Table 3 were approaching full term. The presence of embryos with these dimensions in September, 16 mm. embryos in June from Delaware Bay, along with 81 mm. and 109 mm. embryos taken in July and September respectively by Joseph and Yerger (*Florida State Univ. Stud., No. 22, Pap. Ocean. Inst. 2:111–156*, 1956) from the Gulf of Mexico indicates that pregnancy occurs during the summer months for this species. This is in contrast to the observations made on *G. altavela* where pregnancy occurred during the summer-fall and winter-spring periods. The evidence would also suggest a gestation period of only a few months for *G. micrura* as opposed to one year as speculated by Joseph and Yerger (*op. cit.*).

The remains of one fish was found in the stomachs of each of two rays. The remaining stomachs were empty.

Thanks are due to Fred Sieling of the Maryland Department of Research and Education, Solomons, Maryland for making the Chincoteague Bay specimen of *G. micrura* available, and to Stewart Springer and James L. Squire, Jr. both of the U. S. Fish and Wildlife Service, for providing facilities aboard the M/V *Delaware* and for making available the specimens of *G. altavela* taken in February, 1958. Some of the 1959 collection data was obtained by Paul W. Hess for which the authors are appreciative. The 1958 observations along with those in 1959 were made possible by a National Science Foundation Research Grant, NSF-G 4393. University of Delaware Marine Laboratories Contribution No. 11.—FRANKLIN C. DAIBER, *University of Delaware, Newark, Delaware* AND RICHARD A. BOOTH, *University of Connecticut, Storrs, Connecticut.*

TABLE 3

DIMENSIONS AND SEX OF *Gymnura micrura* EMBRYOS FROM DELAWARE AND CHINCOTEAGUE BAYS

| Disk width of parent in inches | Disk width (in mm.) | | Weight (in gm.) | | Sex |
|---|---|---|---|---|---|
| | Mean | Range | Mean | Range | |
| 32½ | 233 | 223–239 | 153 | 145–170 | 5 ♂ |
| 34 | 16 (TL)* | — | — | — | 5† |
| 34¼ | 200 | 195–207 | 97 | 85–106 | 3 ♀, 2 ♂ |
| 35½ | 245 | 239–256 | 168 | 153–199 | 5 ♀ |

* Total Length
† Indeterminate

LOCAL MOVEMENT IN *MENIDIA* AND *FUNDULUS*.—Little is known about the movement of small, near-shore fishes. Williams (*Univ. Calif. Publ. Zool. 59:249–284*, 1956), Bardach (*Ecology, 39:139–146*, 1958), and Hasler (*In:* Buzzati-Traverso, *Perspectives in Marine Biology*, pp. 451–467, 1958.) have pointed out cases of homing and local movement in fishes and have discussed several related problems. The lack of extensive data in this field has prompted us to record here the results of a small study of marked *Menidia menidia* and *Fundulus heteroclitus*.

*Study Area.*—The study area consisted of a series of salt water channels or ditches on the North shore of Lido Beach, Long Island, N. Y. The Channels (Fig. 1) varied from 250 to 300 feet long and averaged 3 feet deep and 4 feet wide. They emptied into the south side of Reynolds channel, a saltwater channel of Middle Bay. The vegetation consisted of low grass and *Salicornia*. During the highest tides of the lunar cycle, the water may flood the area about and between the channels.

At low tide the water leaves these channels except for isolated pools. The fish usually leave the channels as the tide is receding and return as the tide rises. Occasionally fish are trapped in the isolated pools. Here they may fall prey to numerous least and common terns or succumb to the raised thermal change or to the relatively high

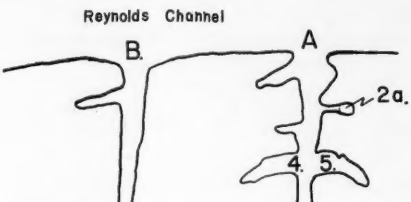


FIG. 1. Diagram of study area, North side Lido Beach, Long Island, N. Y., showing localities mentioned in the text.

TABLE 1

SUMMARY OF MARKED AND RECAPTURED *Menidia* AND *Fundulus*, SEPTEMBER, 1958

| | Species | | | |
|---|---|---|---|---|
| | Fundulus heteroclitus | | Menidia menidia | |
| Place marked | A6 | B1 | A6 | B1 |
| Sept. 4 | | | | |
| Number marked | 51 | 117 | 8 | 5 |
| Sept. 5 | | | | |
| Number caught | 57 | 208 | 9 | 30 |
| Number marked fish caught[1] | 2 | 7 | 1 | 1 |
| Sept. 6 | | | | |
| Number caught | 47 | 95 | 12 | 23 |
| Number marked fish caught | 1 | 6 | 0 | 1 |
| Sept. 7 | | | | |
| Number caught | 22 | 55 | 21 | 74 |
| Number marked fish caught | 2 | 2 | 0 | 2 |
| Sept. 8 | | | | |
| Number caught | 25 | 71 | 11 | 10 |
| Number marked fish caught | 3 | 0 | 0 | 0 |

[1] All fish were recaptured in the channel in which they were first marked. None were found in the other channel.

temperatures of the small pools which are exposed to full sun.

*Methods.*—Fish were collected using a 10-foot seine during high tide. They were marked by fin clipping, measured, and immediately returned to the same channel or tributary in which they were caught. The channels were seined at high tide again on the following four days (Sept. 5–8, 1958). Approximately equal time (1 hour) was spent seining each day. The data reported here is a repeat of similar work done in July 20–28, 1958 (different fins were clipped in the two studies) which had similar results.

We have profited in the interpretation of our data by the field studies of Mr. Robert Croker and Mr. John Randolph on *Fundulus* and by the underwater observations of Mr. Andrew McErlean on *Menidia* and *Fundulus*.

*Results.*—A summary of the fishes collected, marked and recaptured in September is presented in Table 1. All fish labeled "recaptured" were caught in the same channel in which they were marked. None were found in the other channel.

In a previous study, July 20–28, 1958, 187 *F. heteroclitus* were tagged in Channel A of which a total of 12 returned to the same channel. At the same time 162 *M. menidia* were collected in Channel A and of these 17 returned. Some of these *Fundulus* and *Menidia* returned to the same divisions of the channel while others did not (Tables 2–3).

*Miscellaneous observations.*—The main predators of *Fundulus* in this locality are the common and least terns and crabs. (*Libinia, Callinectes, Uca*).

When *Fundulus* ascend the channels there is a limited thermal control of movement. They apparently will not travel in or enter water that is too warm.

Small fish appeared to ascend the streams on the sides; larger fish in the center of the channel.

*Discussion.*—We interpret these results in the following way: *Menidia* occur "offshore" in Reynolds Channel in small schools. When the tide rises, *Menidia* ascend the small channels to avoid

TABLE 2

SUMMARY OF MARKED AND CAPTURED *Menidia*, JULY 20–28, 1958

| Place Marked | Number Marked | Number Recaptured | Place Recaptured | | |
|---|---|---|---|---|---|
| | | | A4 | A5 | A6 |
| A4 | 16 | 3 | 0 | 2 | 1 |
| A5 | 30 | 1 | 1 | 0 | 0 |
| A6 | 116 | 13 | 3 | 3 | 7 |

TABLE 3

SUMMARY OF MARKED AND CAPTURED *Fundulus*, JULY 20–28, 1958

| Place Marked | Number Marked | Number recaptured | Place recaptured | | | |
|---|---|---|---|---|---|---|
| | | | A4 | A5 | A6 | A2a |
| A4 | 12 | 0 | 0 | 0 | 0 | 0 |
| A5 | 10 | 2 | 1 | 0 | 1 | 0 |
| A6 | 15 | 2 | 0 | 0 | 2 | 0 |
| A2a | 150 | 8 | 0 | 0 | 0 | 8 |

predation in the main channel, to feed, to breed (David, 1939, COPEIA: *76;* Rubinoff *MS.*) or to find warmer temperatures (cf. Barlow, *Ecology, 39: 580–587,* 1958.). When the tide goes out, the *Menidia* also leave. In the main channel the schools move about and may move up or down Reynolds Channel several yards. Thus at the next high tide they may or may not ascend the same stream; more than likely they have drifted as a group and ascend some other stream.

*Fundulus* on the other hand, ascend the channels primarily for food (fish ascending the channel have empty stomachs, those leaving have food in their stomachs) and to lay eggs (female in July had eggs; *F. luciae* bred in 1959 on Long Island in late May). Unlike the *Menidia,* they do not remain in the channels (Exit A and B), but when the tide is high enough they go into the grass and *Salicornia.* As the tide goes out, the *Fundulus* follow the "path of least resistance" as the water leaves the higher ground. This results in an individual *Fundulus* either returning to its "own" stream and then to Reynolds Channel or to another channel and then to Reynolds Channel. While in Reynolds Channel, the *Fundulus* stay closer to the shore than *Menidia;* often hiding in reeds and under floating objects. When the tide rises the *Fundulus* ascend the channels. From the data above, it appears that they do not travel far from the mouth of the channel that they descended, and hence will usually return to the same stream just by chance. Continued daily movements through the grass and about the mouths of the channels results in that after several days the number of original *Fundulus* in the same stream is reduced.

*Conclusions.*—1. The number of marked *Fundulus* and *Menidia* returning to a stream in which they were tagged decreases from day to day. 2. The rate of decline is faster in *Menidia* than in *Fundulus.* 3. These differences are related to general swimming activity, schooling behavior, and feeding of the two species. 4. We interpret these results not as homing, but a result of chance localization of activity.—ALFRED BUTNER AND BAYARD H. BRATTSTROM, *Department of Biology, Adelphi College, Garden City, Long Island, New York.*

**A PRELIMINARY LIST OF THE FISHES FOUND IN THE FRESH WATERS OF CONNECTICUT.**—The only publication concerned with the freshwater fishes of Connecticut (Webster, *State Geol. Nat. Hist. Surv. Bull. 63,* 1942.) listed 40 species taken from lakes and ponds. Since then, information on distribution of Connecticut fishes in streams as well as lakes and ponds has been augmented by the staff and students of the University of Conecticut and by the State Department of Fish and Game. The Vertebrate Zoology Collection at the University of Connecticut was established in 1950 by the junior author to serve as a permanent repository of northeastern North American forms. Collections from much of Connecticut have been added since that time, with least complete coverage in the southwestern part of the state. The collection of the Wildlife Management section at the University has been greatly enlarged since Dr. Russell P. Hunter joined the staff.

This list includes all fishes known to occur in the freshwaters of the state. The following fish have been recorded from the Housatonic or Connecticut rivers in Massachusetts by McCabe (*Mass. Fish and Game Rept.* 1946.), the lower Hudson by Greeley (*26th Ann. Rept. N. Y. Cons. Dept.,* 1937), or from Long Island by Greeley (28th Ann. Rept. N.Y. Cons. Dept.,1939.) and may be expected to occur in Connecticut: eastern sturgeon sucker, *Catostomus catostomus catostomus*; dwarf sturgeon sucker, *Catostomus catostomus nannomyzon*; northern redbelly dace, *Chrosomus eos*; silvery minnow, *Hybognathus nuchalis*; bluntnose minnow, *Pimephales notatus*; fathead minnow, *Pimephales promelas*; lake chub, *Couesius plumbeus*; tadpole madtom, *Noturus gyrinus*; yellow bullhead, *Ictalurus natalis*; eastern mudminnow, *Umbra pygmaea*; trout perch, *Percopsis omiscomaycus*; and pirate perch, *Aphredoderus sayanus.* The three-spine stickleback, *Gasterosteus aculeatus,* has been collected in protected coastal areas in Connecticut and would be expected to enter brackish to fresh waters.

Linsley (*Amer. Jour. Sci. and Arts, 47:71,* 1844.) reported the occurrence of the burbot, *Lota lota* (Linnaeus), from Canaan, Connecticut. This species is common in the Connecticut River drainage in New Hampshire, but absent in the Housatonic River drainage, in which Canaan is located. In view of this, the burbot is not included as an authentic Connecticut record.

This list was prepared to provide stimulus for further work on the distribution and ecology of the fishes of inland and tidal fresh waters of Connecticut. If any of the species cited above, or species new to the ichthyfauna of the State, are found in these waters, the collector is urged to forward the specimen and accompanying data to the University of Connecticut.

When many authentic records occur over much of the State, no specific data on the authority or location of specimens is given. The species is simply listed as "common". When few records exist, the following abbreviations and other annotations are used in the list below: UCZ—Verte-

brate Zoology Collection, University of Connecticut; UCWM—Wildlife Management Collection, University of Connecticut; and CFG—Specimens collected by or reliably reported to the Connecticut State Fish and Game Department. These records are augmented by a few literature citations. Habitat abbreviations given below are as follows: F—Freshwater; B—Brackish; A—Anadromous; and C—Catadromous. An asterisk preceding the scientific name indicates that the species has been introduced.

## Annotated List

### Petromyzontidae

*Petromyzon marinus*, sea lamprey. A; Eightmile River (Conn. R. tributary), UCWM.

*Lampetra lamottei*, American brook lamprey. F; Kettle Brook, Windsor Locks, UCWM.

### Acipenseridae

*Acipenser oxyrhynchus*, Atlantic sturgeon. A; Conn. R. CFG.

*A. brevirostrum*, shortnose sturgeon. A; Conn. R. CFG.

### Amiidae

**Amia calva*, bowfin. F; Lake Zoar, Webster (1942, Conn. Geol. and Nat. Hist. Surv. Bull. (63):127).

### Clupeidae

*Alosa sapidissima*, American shad. A; Conn. R. CFG.

*A. pseudoharengus*, alewife. A; Common.

*A. aestivalis*, glut herring. A; Conn. R. CFG.

*A. mediocris*, hickory shad. A; Conn. R. CFG.

*Brevoortia tyrannus*, Atlantic menhaden. B; Often enters tidal streams.

### Engraulidae

*Anchoa mitchilli*, bay anchovy. B; Tidal streams.

### Salmonidae

**Oncorhynchus nerka*, sockeye salmon. F; East Twin Lake, UCZ.

*Salmo salar*, Atlantic salmon. A; Last Conn. record 1948 (Merriman and Jean, 1949. Copeia (3): 200–201).

**S. gairdneri*, rainbow trout. F; Common.

**S. trutta*, brown trout. F; A; Common.

*Salvelinus fontinalis*, eastern brook trout. F; Common.

**S. namaycush*, lake trout. F; East Twin Lake and Lake Wononscopomuc, CFG.

*Prosopium cylindraceum*, round whitefish. F; East Twin Lake, UCZ.

### Osmeridae

*Osmerus mordax*, smelt. F; B; Crystal Lake, Ellington, UCZ.

### Anguillidae

*Anguilla rostrata*, American eel. C; Common.

### Catostomidae

*Catostomus commersoni*, white sucker. F; Common.

*Erimyzon oblongus*, creek chubsucker. F; Common.

### Cyprinidae

*Notemigonus crysoleucas*, golden shiner. F; Common.

*Semotilus corporalis*, fallfish. F; Common.

*S. atromaculatus*, creek chub. F; Common.

*Notropis cornutus*, common shiner. F; Common.

*N. hudsonius*, spottail shiner. F; Common.

*N. bifrenatus*, bridled shiner. F; Common.

*Rhinichthys atratulus*, blacknose dace. F; Common.

*R. cataractae*, longnose dace. F; Salmon Brook, Granby, UCWM.

*Exoglossum maxillingua*, cutlips minnow. F; Common.

**Cyprinus carpio*, carp. F; Common.

**Carassius auratus*, goldfish. F; Common.

**Tinca tinca*, tench. F; Wattles Pond, Watertown (Webster, 1942 *op. cit.* p. 154).

### Ictaluridae

**Ictalurus punctatus*, channel catfish. F; CFG.

**I. catus*, white catfish. F; Fall Mountain Lake, Terryville, UCWM.

**I. melas*, black bullhead. F; Conn. R. CFG.

*I. nebulosus*, brown bullhead. F; Common.

### Esocidae

**Esox lucius*, northern pike. F; Conn. R. (Webster, 1942 *op cit.* p. 166).

*E. niger*, chain pickerel. F; Common.

*E. americanus*, redfin pickerel. F; Common.

### Cyprinodontidae

*Fundulus heteroclitus*, mummichog. B; Common.

*F. diaphanus*, banded killifish. F; B; Common.

*Cyprinodon variegatus*, sheepshead minnow. B; Common.

*Lucania parva*, rainwater killifish. B; UCWM.

### Gasterosteidae

*Eucalia inconstans*, brook stickleback. F; Conn. R. UCZ; Plainville, UCWM.

*Pungitius pungitius*, ninespine stickleback. B; Common.

*Apeltes quadracus*, fourspine stickleback. B; Common.

Atherinidae

*Menidia menidia*, Atlantic silverside. B; Common.

*M. beryllina*, tidewater silverside. B; Common.

Percidae

*Perca flavescens*, yellow perch. F; Common.

**Stizostedion vitreum*, walleye. F; Stocked, Lake Lilliontahl, Housatonic R. 1955, CFG.

*Etheostoma nigrum*, Johnny darter. F; Common.

*E. fusiforme*, swamp darter. F; Quinnabaug drainage, UCZ.

Centrarchidae

**Micropterus dolomieui*, smallmouth bass. F; Common.

**M. salmoides*, largemouth bass. F; Common.

**Lepomis cyanellus*, green sunfish. F; Haviland Brook, Stamford, Fenton R. Mansfield UCZ, UCWM.

*L. auritus*, redbreast sunfish. F; Common.

**L. macrochirus*, bluegill. F; Common.

*L. gibbosus*, pumpkinseed. F; Common.

**Ambloplites rupestris*, rock bass. F; Common.

**Pomoxis nigromaculatus*, black crappie. F; Common.

**P. annularis*, white crappie. F; Conn. R. CFG.

*Enneacanthus obesus*, banded sunfish. F; Rogers Lake, Lynne, UCZ.

Serranidae

*Roccus americanus*, white perch. F; B; Common.

*R. saxatilis*, striped bass. A; B; Common.

Cottidae

*Cottus cognatus*, slimy sculpin. F; Hop R., Andover, Indian Hollow Brook, Windham, UCZ; Salmon Brook, Granby, UCWM.

This list was prepared under the Seniors' Distinction Program of the Department of Zoology and Entomology, University of Connecticut, with the cooperation of the Wildlife Management section of the Department of Plant Science, University of Connecticut. We express our sincere appreciation to Dr. Reeve M. Bailey for information and advice on recent changes in nomenclature. The common names are those recommended by the Committee on Names of Fishes of the American Fisheries Society.—ROBERT J. BEHNKE, *Department of Zoology, University of California, Berkeley 4, California,* AND RALPH M. WETZEL, *Department of Zoology, University of Connecticut, Storrs, Connecticut.*

NOTES ON THE EARLY GROWTH AND ALLOMETRY OF THE NORTHERN PIKE, *ESOX LUCIUS* L.—During a study of the early life history of the northern pike, *Esox lucius* L. observations on early development and allometric growth relationships were made.

At time of hatching, fry vary in total length from 6.5–8.0 mm. The mouth is not developed and only the pectoral and caudal fins are present. By the time the fishes have attained lengths ranging from 10.5–12.0 mm. the mouth has developed, the gill covers are open, and the paired fins are noticeable. Between body lengths of 12 and 25 mm. the tail shifts gradually from the heterocercal to the homocercal condition and at lengths of 35–40 mm. the fish have assumed the general form of the adults (Fig. 1).

Analysis of allometric growth using 90 fish between 25 and 115 mm. in total length was made. These fish were held in a trap for varying periods of time; thus, girth or width measurements were not made because the extent of stomach disten-

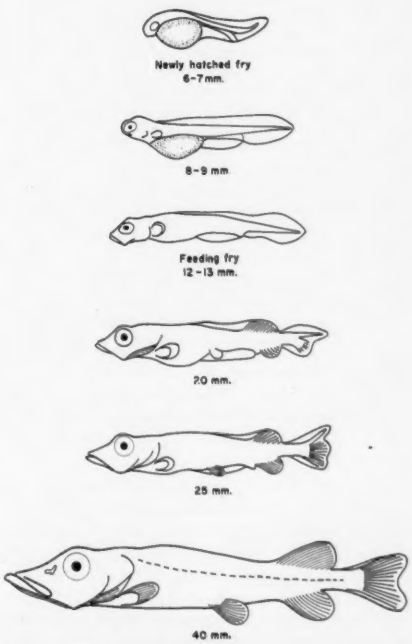


FIG. 1.—Successive developmental stages of fry and fingerlings of northern pike, *Esox lucius*, at Lake George, Minnesota, illustrating changes in general external morphology.

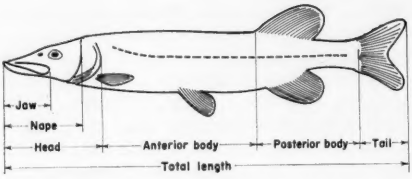


FIG. 2.—Measurement points used for allometric growth analysis of northern pike fry and fingerlings.

TABLE 1.

ALLOMETRIC GROWTH OF BODY REGIONS AND HEAD REGIONS IN 90 FINGERLINGS OF THE NORTHERN PIKE, *Esox lucius*—EXPRESSED AS PERCENTAGE OF HEAD OR TOTAL LENGTH IN MM.

| Mid-point length interval | Mean total length | Percentage of total length | | | | Mean head length | Percentage of head length | |
|---|---|---|---|---|---|---|---|---|
| | | Head | Anterior body | Posterior body | Tail | | Jaw | Nape |
| 30 | 30.78 | 33.0 | 35.8 | 21.0 | 9.9 | 9.90 | 36.7 | 76.4 |
| 40 | 40.89 | 33.6 | 34.4 | 20.9 | 11.2 | 13.73 | 38.6 | 75.4 |
| 50 | 51.39 | 33.1 | 33.8 | 21.0 | 12.0 | 16.97 | 40.2 | 75.1 |
| 60 | 61.01 | 33.5 | 32.8 | 21.2 | 12.6 | 20.41 | 41.3 | 73.7 |
| 70 | 68.50 | 33.1 | 32.7 | 21.6 | 12.6 | 22.64 | 41.5 | 74.1 |
| 80 | 79.81 | 32.6 | 33.0 | 21.6 | 12.3 | 26.12 | 41.4 | 73.4 |
| 90 | 90.64 | 32.5 | 33.6 | 21.5 | 12.5 | 29.39 | 42.4 | 72.1 |
| 100 | 99.96 | 32.0 | 33.3 | 22.3 | 12.3 | 31.78 | 42.3 | 72.4 |
| 110 | 109.71 | 31.9 | 33.8 | 21.6 | 12.8 | 34.95 | 42.4 | 77.1 |

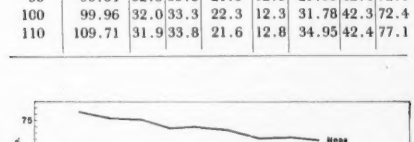


FIG. 3.—Allometric growth relationships in various body regions of the northern pike expressed as percentage of total length; and in regions of the head expressed as percentage of head length.

sion was variable. All measurements were made under 3× magnification to the nearest 0.1 mm. with a vernier caliper. All the measurement points (Fig. 2) were not equally good. Difficulty was encountered on some fish in measuring anterior and posterior body lengths because the point of insertion of the dorsal fin could not always be precisely located externally. The measurement of nape length was made between the snout and the most posterior pair of pits on top of the head. This measurement was good on fish longer than 45 mm. but was somewhat uncertain on the smaller fish.

Body measurements were expressed as percentage of total length and jaw and nape measurements were expressed as percentage of head length (Table 1, Fig. 3). The growth of the jaw and tail was much more rapid than that of the body up to a length of about 65 mm., but after that length was attained growth in all regions of the body and head was relatively constant. These relationships would be expected since the jaw is one of the most poorly developed regions of the fry and the tail is developing as shown.—DONALD R. FRANKLIN AND LLOYD L. SMITH, JR. *Department of Entomology and Economic Zoology, University of Minnesota, St. Paul, Minnesota.* (Paper No. 4205, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota).

THE SWIMBLADDER OF *VELIFER HYPSELOPTERUS*.—The family Veliferidae, representatives of which are scarce in collections, is known only from the Indo-Pacific. The members are the least specialized of the order Lampridiformes (Allotriognathi). An expression of gratitude is due N. B. Marshall of the British Museum (Natural History), who gave permission to examine the internal structure of BM (NH) 1849.10.9.16, a partially eviscerated Japanese specimen of *Velifer hypselopterus*, 165 mm. in standard length.

As shown in Fig. 1 the swimbladder is 81 mm. long, beginning close behind the head and terminating approximately midway between the vertical of the anus and the base of the caudal fin. The caudal portion consists of a pair of slender, conical chambers lying on either side of the series of haemal spines; these chambers lead into the dorsal portion of the large anterior chamber. When fully inflated the anterior chamber is subtriangular in lateral aspect, with the posterior face concave. The vascular supply (presumably the rete mirabilis) consists of several vessels which run as a bundle from the dorsal side of the esophagus to the inner lining of the swimbladder, passing through a lenticular opening in the tunica externa near the cranial end of the anterior chamber. The morphology of the red gland and the paths of the blood vessels along the esophagus

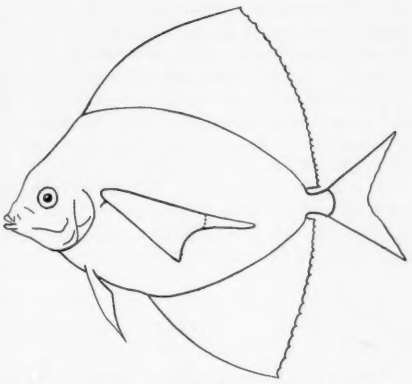

FIG. 1.—Outline of swimbladder in *Velifer hypselopterus*.

cannot be made out; the fish was given a collection number 111 years ago and time has not been kind to these finer structural details. The walls of the anterior chamber are provided with a pair of intrinsic muscles, more robust on the ventral surface, originating on the first haemal spine at the posterior end of the body cavity, and terminating at the anterior end of the swimbladder; there are no other muscular connections between the swimbladder and the body. A long, round, solid tendon connects the anterior end of the swimbladder with the first haemal spine; the tendon is bound to the ventral face of the swimbladder for its entire length, and lies to the left of the rete.

The structure of the swimbladder suggests it may serve as an acoustic transducer. The muscles on the ventral face of the anterior chamber are therefore identified as "drumming muscles", and the name "polyhymnic tendon" is proposed for the tendon since Polyhymnia was the Muse of Song. The possible relationships of the size and shape of the swimbladder to its resonance and the directionality of the generated sound beam are tempting to speculate upon but beyond the limits of our information. The drumming muscles and/or polyhymnic tendon of *Velifer* may be homologous with the ink sac of the Lophotidae; a comparison between the swimbladders of *Velifer* and other lampridiform fishes will be given in a separate publication.—VLADIMIR WALTERS, *American Museum of Natural History, New York 24, N. Y.*

A RECORD OF THE PORBEAGLE, *LAMNA NASUS*, FROM COOK INLET, ALASKA.—Clemens and Wilby (*Fish. Res. Bd. Canada., Bull. 68: 52–53,* 1946.) stated that the porbeagle, widely known as mackerel shark, *Lamna nasus* (Bonnaterre), is common along the Canadian coast with a range extending from northern California to northwestern Alaska. In recent years local reports have increased about the damage to fishermen's net from this lamnid. Although the porbeagle is well known in the general area of Cook Inlet, this is the first known recorded account from Kachemak Bay, Alaska.

On July 18, 1959, Mr. William Parker of Seldovia, Alaska, while fishing for salmon in Kachemak Bay, caught a porbeagle in the deep end of a gill set-net. Two days later, on July 20, 1959, a second specimen was taken in the same manner at a location one mile distant from the earlier capture. The first specimen was a mature male which weighed an estimated 120 pounds, while the second, a female, weighed an estimated 180 pounds.

Measurements for both sharks are recorded together, the first being that of the female and the second the male. Trunk at origin of pectorals: breadth 260, 245 mm.; height 240, 225 mm. Mouth: breadth 152, 145 mm. First dorsal fin: vertical height 268, 254 mm. Left pectoral fin: outer margin 395, 389 mm. Tail: vertical height from vertebral column 501, 487 mm.; vertical depth from vertebral column 408, 392 mm. Total length: snout to end of vertebral column 1924 mm. (76 inches), 1696 mm. (67 inches). Male clasper: length 24 mm.

Analysis of the stomach contents taken from the male specimen revealed the following identifiable fragments: muscle and vertebrae from a Pacific tomcod, *Microgadus proximus* (Girard); vertebral segments from *Oncorhynchus nerka*, a red or sockeye salmon; muscle, vertebrae, and part of a head from a cottid, probably *Hemilepidotus hemilepidotus* (Tilesius); and muscle and vertebrae from a pink salmon, *Oncorhynchus gorbuscha* (Walbaum) or a chum salmon, *Oncorhynchus keta* (Walbaum). Fish identifications were made by comparison with preserved whole specimens previously identified using the key of Wilimovsky (*Fish. Res. Lab., U.S. Fish. Wildl. Serv., Juneau: 1–113,* 1958.).

The porbeagle, easily identifiable according to the key of Clemens and Wilby, is readily distinguished from other sharks in the area by: the keel on each side of the caudal peduncle; and the moderate length of the gill slits. The male specimen had a mottled gray dorsum rather than the typical solid bluish gray, while the female was typically colored. The male had three wound areas on the lateral surfaces, approximately one inch long, each heavily infested with a parasitic copepod, probably *Chondracanthus*. The gills of

the female were similarly infested.—DONALD B. BRIGHT, *Department of Biology, University of Southern California, Los Angeles, California.*

LARVAE OF TARPON, *MEGALOPS ATLANTICA*, FROM THE AÑASCO RIVER, PUERTO RICO.—Another clue in the life history of the tarpon, *Megalops atlantica* Valenciennes, was revealed on September 27, 1959, when 11 larvae of this species from 24 to 26 mm. standard length were caught from the Añasco River, Puerto Rico. The tarpon were captured with a dip net near the surface in open river water about 300 yards above the actual river mouth (where it joined the sea). The tarpon were located in muddy freshwater near a small stand of cattails slightly inshore of the main downstream current. The river was at average or below average flood stage level for that time of year, the rainy season.

These tarpon larvae appeared in development to be between the 18 mm. leptocephalus tarpon taken in a plankton tow "... about 150 miles east and slightly north of Brunswick, Georgia" by Gehringer (*Quart. Jour. Fla. Acad. Sci. (1958), 21(3):235–240,* 1959.) and the smallest of the 259 postlarval tarpon from Indian River, Florida, recorded by Harrington (COPEIA *1958(1):1–10).*

The author has followed the terminology used for *Elops saurus* (Gehringer, *U.S. Fish and Wildl. Serv. Fish. Bull. 59(155):619–647* 1959.) and believes that the tarpon larvae are approximately equivalent in development to the *Elops* "... early metamorphic larva, 26.6 mm. standard length" (p. 627, fig. 10). With the clear formation of the dorsal, caudal, and anal rays, the Añasco tarpon resemble the early metamorphic larva more than the leptocephalus. The ray counts of D, 11–12 and A, 20–21 agree with those given by Gehringer for the tarpon. Harrington's "smallest recorded post-larval tarpon—16 mm. S. L." (p. 6, fig. 5) appears similar to the shrunken "mid-metamorphic larva of Gehringer's *Elops*. All Harrington's 259 tarpon larvae appear to be more advanced in development than the Añasco tarpon.

Harrington infers (p. 2) that his tarpon entered the marshes from the Indian River. The younger Añasco tarpon in the main stream of the river tend to corroborate the probability that the Florida tarpon were in the main stream of the Indian River at an earlier stage of larval development.

The Añasco tarpon larvae were collected along with 15 early metamorphic larvae of *Elops* (from 26 to 30 mm. S. L.). Small postlarval gobies *Sicydium plumieri* and small shrimps were abundant in the same catches. The gobies and shrimp were migrating upstream from the sea. The upstream migration of gobies *S. plumieri* is a well known phenomenon in the West Indies. From about July to December, this migration regularly occurs about two days after the third quarter of the moon; the migration is about two days in duration. It is probable that the tarpon were moving upstream with the gobies.

The author is indebted to Jack W. Gehringer for help in the identification of these tarpon and ten-pounder larvae.—DONALD S. ERDMAN, *Box 412, Lajas, Puerto Rico.*

FURTHER OCCURRENCE OF THE CALIFORNIA POMPANO, *PALOMETA SIMILLIMA* (AYRES), IN PUGET SOUND, WASHINGTON. —The capture of the California pompano, *Palometa simillima* (*-Peprilus simillimus*), in Washington and British Columbia waters is a relatively rare event. Clemens and Wilby (Fish. Res. Bd. Canada, Bull. *68:1–368,* 1946.) record five specimens from 1903–1941 in the British Columbia waters. Kincaid (State of Washington, Dept. of Fish., 51 pp., 1919.) lists the pompano in an annotated list of Puget Sound fishes. Starks (Proc. Calif. Acad. Sci. *ser. 2, 6:549–562,* 1896.) saw one specimen in a collection of fishes from Port Ludlow, Washington. Schultz (Univ. Wash. Publ., *2(4):103–228,* 1936.) records the pompano as occurring from Puget Sound to San Diego.

On September 23, 1958, one specimen of *P. simillima,* 173 mm in fork length, was taken in a fish trap at La Conner, Skagit Bay. Two specimens, 191 and 188 mm, were taken at Lagoon Point, Whidbey Island on November 24, 1959, by Mr. Vicent Skimpsey of the Washington Fish Company. The author collected a single specimen, 206 mm (F.L.), aboard the College of Fisheries' M/V COMMANDO trawling in Port Orchard on December 10, 1959. On December 11, 1959, 10 specimens ranging from 179 to 215 (F.L.) mm were collected by Messers. Charles R. Hitz and Elbert L. Milburn on the M/V COMMANDO trawling in Port Orchard. Single specimens, 174 and 185 mm, were collected on different trips, March 1 and 2, 1960 in Port Orchard. These specimens represent the first reported occurrence of the California pompano in mid-Puget Sound waters, thus extending inland by some 30 miles the range shown by Starks (*op. cit.*). The Port Orchard records are of particular interest because in scores of comparable trawl hauls made since 1950 in this restricted portion of Puget Sound not a single pompano has been previously observed.

All specimens are preserved and stored in the Collection of Fishes of the College of Fisheries of the University of Washington (Cat. Nos. 14572,

14621, 14655, 14656, 14699, 14700).—BILLY S. BATTS, *College of Fisheries, University of Washington, Seattle, Washington*. Contribution No. 41 from the College of Fisheries, University of Washington.

*PIKEA SERICEA*, A SYNONYM OF THE AMERICAN CENTRARCHID FISH, *MICROPTERUS SALMOIDES*.—Fowler (*The Hong Kong Naturalist Supplement, No. 6:23–24, fig. 2* 1938.) described in some detail *Pikea sericea*, a supposedly new species of the family Serranidae. The similarity of the figure and of the accompanying data to *Micropterus salmoides* (Lacépède) led us to examine the type specimens, and the recent literature on both groups. Neither Schultz (*Proc. U. S. Nat. Mus., 108(3405):321–329*, 1958.) in his study of the genus *Pikea* and its allies, nor Hubbs and Bailey (*Misc. Publ. Mus. Zool. Univ. Mich., No. 48*, 1940.) in their revision of *Micropterus*, treated *P. sericea*. We have found no mention of the species apart from its original description.

Some confusion exists concerning which of the two specimens is the holotype. Fowler (*op. cit., p. 24*) said that the larger specimen was the type (it is his usual practice to single out the largest of a series as holotype) but the illustration bears the caption "type" and is of the smaller fish. Labels written by Fowler indicate "type" for the smaller fish, ANSP 68289, and "paratype" for the larger, ANSP 68290. We follow this allocation and consider the designation on page 24 in error. Since both specimens represent the same species the problem is of little consequence.

The following data were recorded for the type specimens (in each instance the first figure applies to the holotype, ANSP 68289, the second to the paratype, ANSP 68290): standard length, 123.8, 157.4; number of dorsal rays X-13, XI-12; anal rays, III-11 in both; pectoral rays, 15–15, 14–15; lateral-line scales 64, 62; rows of scales on cheek, 12, 12; scales above lateral line, 7, 7; scales below lateral line, 14, 15; scales around caudal peduncle, 28, 28; meristic index, as defined by Bailey and Hubbs (*Occ. Papers Mus. Zool. Univ. Mich., 516:22*, 1949.), 125, 124. Both specimens possess glossohyal teeth, the paratype a small subcircular patch, the holotype only 4 or 5 teeth in a linear arrangement.

Both specimens represent *Micropterus salmoides*, a common and familiar freshwater species native to eastern North America but widely and successfully introduced elsewhere. No definite locality data were listed by Fowler apart from the general statement "Hong Kong, China". Dr. J. D. Bromhall, of the University of Hong Kong, confirms the presence of *M. salmoides* in reservoirs of that region.

The outline of the spinous dorsal fin in figure 24 is in error since both specimens have the characteristic fin of *salmoides*. The bases of the anal and soft dorsal fins are scaled, a feature shown on the drawing. Use of the meristic index identifies the types of *sericea* with the subspecies *salmoides* rather than with *floridanus*. This is consistent with the probable source of the introduced stock being elsewhere than Florida. The name *sericea* is available should *M. salmoides* be further divided.—Contribution 265 from The Marine Laboratory, University of Miami. C. RICHARD ROBINS, *The Marine Laboratory, University of Miami, Miami 49, Florida and* JAMES E. BÖHLKE, *Chaplin Chair of Ichthyology, Academy of Natural Sciences, Philadelphia 3, Pennsylvania*.

NEW RECORDS OF THE OPISTHOPROCTID GENUS *BATHYLYCHNOPS*, WITH A NOTICE OF NEOTENY IN THE RELATED GENUS *DOLICHOPTERYX*.—Thanks to the kindness of Mr. William Aron of the University of Washington I have examined a fine collection of elongate opisthoproctid fishes from the North Pacific (collected by Mr. Aron during studies supported by the Office of Naval Research, Contract Nonr—477 [10] and by the National Science Foundation). The term "neoteny" in the title and text is used here in the broad sense. See de Beer (*Embryos and ancestors, 3rd edit.*, p. 63, 1958) for further discussion.

These fishes first appeared to be an undescribed species of *Dolichopteryx*; however, further study suggests they are the young of the monospecific genus *Bathylychnops*, hitherto known from only the adult holotype of *B. exilis*.

In the original description of *B. exilis* (Cohen, *Stanford Ichthyol. Bull., 7(3):47*, 1958) four characters were used to separate *Bathylychnops* from *Dolichopteryx*. Three of these characters are discussed in this paper and additional characters are given. Eleven new locality records are listed along with selected counts and measurements (Table 1). In addition, the material is briefly described.

*Vertebral count*.—The holotype of *B. exilis* has 80 vertebrae; eight specimens X-rayed have 80–84 vertebrae. *Dolichopteryx longipes* (type species of *Dolichopteryx*) has 40–43 vertebrae (see Cohen, *supra cit*. Additional data was obtained from three eastern Pacific specimens in the collections of the Scripps Institution of Oceanography. I thank my friend Alfred Ebeling for the X-ray photographs). The holotype of *D. binocularis* has about 52 vertebrae (count based on an X-ray photograph

of the holotype in the U.S. National Museum). Counts are not available for *D. brachyrhynchus* and *D. anascopa*, the other two species described in the genus.

*Teeth.*—The type of *B. exilis* has a single row of teeth on the vomer. The vomerine teeth on the smaller specimens are also in a single row, although the compressed bases may overlap to a considerable extent. In contrast to this, all the vomerine teeth which I have examined in *Dolichopteryx* specimens (*D. longipes, D. binocularis, D. brachyrhynchus*) are in two or more rows.

*Sexual maturity and structural development.*—A remarkable feature of the elongate opisthoproctids is that the early stages of development of many structures, as seen in immature *Bathylychnops*, are also present in sexually mature *Dolichopteryx*. Some examples are: 1. A poorly developed body musculature—The ventral musculature of the body wall is absent; thus the gut is enclosed ventrally by only the peritoneum and the skin. In specimens which are not darkly pigmented ventrally, the entire length of the gut is exposed. The ventral muscle separation continues posteriorly beyond the termination of the gut as far as the anterior procurrent rays of the ventral lobe of the caudal fin. In addition, there is a shallower, distinct dorsal cleavage between the epaxial muscle masses of the two sides. 2. Squamation—Scales are vestigially present. 3. Fins—The paired fins are on prominent peduncles which are not connected to the trunk by muscles. The dorsal and anal fin bases are elevated from the body and appear to float in the membranous tissue which surrounds the body. The pelvic girdle is in two separate halves, on either side of the gut. 4. Pigmentation—The skin is mostly transparent; the color pattern is made up of relatively few, but large chromatophores; the body has dark, ventral blotches. 5. Eyes—The condition of the eyes is intermediate between the non-tubular eyes of adult *B. exilis* and the strongly tubular eyes of all *Dolichopteryx* species I have seen. 6. Luminous tissue—Accessory orbital luminous tissue (in addition to the pronounced orbital photophore) is just beginning to develop in two of the largest specimens (112.5 and 124.5 mm. standard lengths). This tissue is present in larger *Bathylychnops* and is absent in small *Bathylychnops* and in all *Dolichopteryx* which I have seen.

Parr (*Bull. Bingham Oceanogr. Coll., 3*(7):*36, 38*, 1937.) and Roule and Angel (*Res. Camp. Sci. Albert I, 79, pl. 4*, 1930.) have illustrated most of the above conditions in *Dolichopteryx*. It is of interest to note that the latter authors described their specimens as larvae.

It might follow from the above data that all *Dolichopteryx* are the young of unknown, *Bathylychnops*-like adults; however, this is not true for at least two of the species. In *D. longipes*, Beebe (*Zoologica, N.Y., 16:72, 76, 77*, 1933.) reported large eggs in the ovary of a female 85 mm. (S.L.), a testis in a 35.5 mm. male, and eggs in a female 40 mm. (S.L.). I have seen eggs in the ovaries of a specimen of *D. longipes*, 62 mm. (S.L.) (Bingham Oceanographic Collections no. 2715, examined through the courtesy of Dr. James Morrow). In

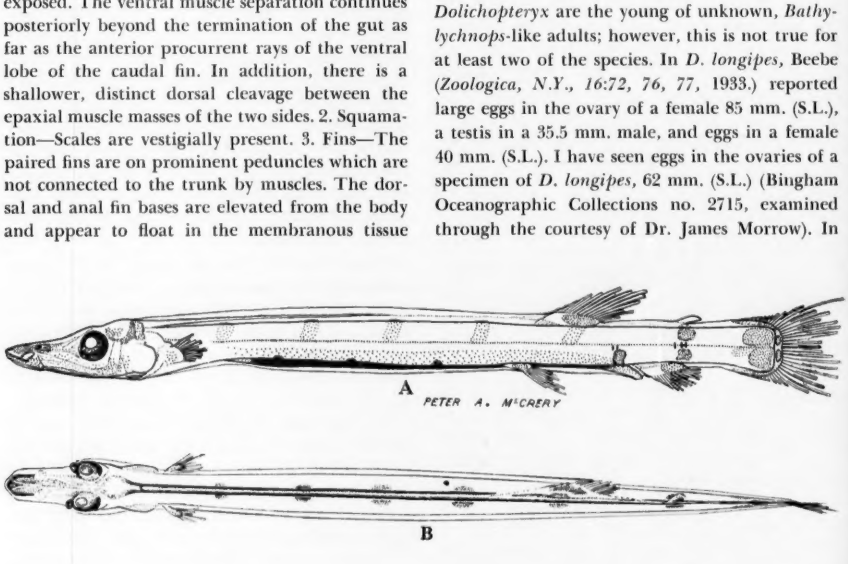


FIG. 1.—*Bathylychnops exilis*. A. Lateral view of a specimen 112.5 mm. standard length, to show the darkly pigmented gut projecting below the lateral musculature. B. Dorsal view of a specimen 112.5 mm. (S.L.). C. Ventral view of a specimen 111.5 mm. (S.L.) to show that the ventral pigmentation is to a degree intermediate between the well-defined blotches of smaller specimens, and the solid pigmentation of larger specimens. Fig. 1A was prepared by Peter McCrery for William Aron at the Department of Oceanography, University of Washington, and emended by Mildred H. Carrington. Fig. 1B and 1C were drawn by Mildred H Carrington.

TABLE 1

LOCALITY DATA AND SELECTED COUNTS AND MEASUREMENTS ON 11 SPECIMENS OF *Bathylychnops exilis*

| Latitude N. | Longitude W. | Fishing depth of net (M.) | Time | Date | Standard length (mm.) | Body depth (mm.) | Dorsal rays | Anal rays | Ventral rays | Pectoral rays | Vertebrae (Urostyle not counted) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 39°37.5′ | 135°21.5′ | 60 | 0010–0047 | 7/19/58 | 112.5 | 6.5 | 14 | 14 | 7 | 13 | 82 |
| 39°35.1′ | 141°53′ | 225 | 0308–0406 | 7/16/58 | 124.5 | 8.4 | 16 | 13 | 7 | — | 81 |
| 41°06′ | 133°02′ | 60 | 0007–0045 | 8/10/58 | 94.5 | 4.5 | 15 | 14 | 7 | 12 | 82 |
| 38°24.9′ | 139°37.1′ | 225 | 1331–1429 | 7/17/58 | 101.0 | 6.0 | 15 | 14 | 7 | 13 | 81 |
| 42°51.8′ | 135°28.5′ | 225 | 0139–0238 | 8/11/58 | 105.0 | 5.0 | 16 | 14 | 7 | 13 | 84 |
| 38°34.6′ | 131°32.2′ | 400 | 1655–1810 | 8/11/58 | 90.0 | 5.5 | 13 | 13 | 7 | 13 | 81 |
| 39°50′ | 142°10′ | 60 | 0004–0042 | 7/19/58 | 113.5 | 4.8 | — | — | — | 13 | 84 |
| 39°50′ | 142°10′ | 60 | 0004–0042 | 7/19/58 | 111.5 | 4.5 | 15 | 13 | 7 | 13 | 80 |
| 38°51′ | 141°58′ | 120 | 0127–0210 | 7/18/58 | 42.8 | — | 15 | — | 7 | 12 | — |
| 38°49.6′ | 137°56.1′ | 30 | 0045–0120 | 7/18/58 | 55.0 | 3.6 | 14 | 13 | 7 | 13 | — |
| 39°45.5′ | 142°02.9′ | 120 | 0126–0209 | 7/16/58 | 25.0 | — | — | — | — | — | — |
| 38°55.7′ | 137°36.7′ | 225 | 0307–0403 | 7/18/58 | 46.0 | — | — | — | 7 | 13 | — |

addition, Parr (*op. cit.*) stated that the type of *Dolichopteryx brachyrhynchus* is a mature male.

Neoteny in *Dolichopteryx* may be an important character in separating this genus from *Bathylychnops*. Additional material of *D. binocularis* and *D. anascopa* is needed to check these species for gonadal development and to examine the development of the structures noted above. These two species may belong in *Bathylychnops*.

*Color Pattern of Young Bathylychnops* (Fig. 1). —The body is a translucent white, suggesting that the specimens may be transparent in life. The muzzle is dusky; dark pigment is present in the lateral walls of the brain case and visible through the skull. A dorsal and a ventral series of dark blotches are present along the body. The dorsal series consists of 6 pairs of evenly-spaced blotches of dark brown pigment which are located on the inner faces of the epaxial muscle masses. These blotches are plainly visible from a dorsal view. Seen laterally, they are visible through the muscles. The blotch between the dorsal and caudal fins is spread out onto the outside of the muscle masses and forms a saddle over the caudal peduncle. The fifth blotch is immediately below the base of the dorsal fin, which is also dark brown. The base of the caudal fin also bears a dark lateral blotch which, when viewed from above, appears to be number seven of the dorsal series.

Seven to nine blotches are present ventrally. The anterior-most five or six are present on the peritoneum and the overlying skin. One of the blotches lies between the similarly pigmented bases of the ventral fins, while the last blotch is between the hypaxial muscle masses above the darkly-pigmented anal fin base. It also extends up on the sides of the caudal peduncle to where it almost meets the last dorsal blotch. The other dorsal and ventral blotches do not coincide with each other, but alternate. Three of the larger specimens have the ventral series of blotches obliterated by a solid, dark-brown or black peritoneum. Two specimens show an intermediate condition between blotches and solid coloring. The pattern of blotches on a clear peritoneum is evidently a juvenile character as the adult, type of *B. exilis*, has a dark peritoneum.

*Viscera.*—All specimens observed had an elongate blind sac, similar to the one shown by Beebe (*op. cit.*) in *Dolichopteryx*, branching off from the intestine a short distance behind the level of the pectoral fins and extending posteriorly a considerable distance. A specimen 105 mm. (S.L.) had a sac over 30 mm. long.

In two *Bathylychnops* specimens 105 mm. and 90 mm. (S.L.) the paired kidneys are elongate structures which extend the entire length of the body cavity.

*Dorsal fin rays.*—A count of 12 was originally given for the holotype of *B. exilis*. This is one lower than the extreme for the material herein reported upon (Table 1). Reexamination of the type shows that the dorsal fin was damaged, and there may have been as many as 15 dorsal-rays.—DANIEL M. COHEN, *U. S. Dept. of Interior, Fish and Wildlife Service, Bur. Comm. Fish., Ichthyol. Lab. Washington, D. C.*

RECAPTURES OF TUNA, MARLIN AND SAILFISH TAGGED IN THE WESTERN NORTH ATLANTIC.—For some years, the Woods Hole Oceanographic Institution has been conducting a program of marking pelagic gamefishes with the cooperation of many sport fishermen and their organizations and also of the U. S.

Fish and Wildlife Service, the Marine Laboratory of the University of Miami, and other research establishments. Small scale experiments with marked hooks and opercular strap tags in 1951–1953 were unsuccessful. In 1954, plastic dorsal loop tags (Type G, Wilson, *Cal. Fish and Game, 39 (4):429–442,* 1953.) were used to mark small bluefin tuna, *Thunnus thynnus* (Linnaeus), off Massachusetts. Additional small bluefin tuna as well as some very large ones, and a few Atlantic sailfish, *Istiophorus albicans* (Latreille), and white marlin, *Makaira albida* (Poey), were marked with dart tags. These, first designed by the author in that year and subsequently refined in several ways, consist of a plastic streamer attached to a harpoon-like stainless steel dart which is set in the flesh of the fish. In subsequent years, dart tags, including since 1958 the all-plastic FT-1 type produced by the Floy Tag and Manufacturing Co., Seattle, Washington, have been used almost exclusively. By May, 1959, approximately 600 bluefin tuna, 750 white marlin, and 115 Atlantic sailfish had been marked, as well as many fish of other species. Tags from 5 bluefin tuna, 3 Atlantic sailfish, and 2 white marlin had been recovered up to the end of 1959 (Table 1). Those from the 3 tuna marked in 1954 were of the dorsal loop type; the others were dart tags.

The most important result is the proof of the trans-Atlantic migration of 2 bluefin tuna. It has been widely believed that the eastern and western Atlantic populations of bluefin tuna were distinct, due to slight differences in proportions and counts (Ginsburg, Copeia 1953, *(1):1–10*; Rivas, *Final Report 54–1, Charles F. Johnson Found., Mar. Lab., Univ. of Miami: 1–5 mimeo,* 1954.). Much more tagging will be required to determine the extent to which the populations intermingle. Next in importance is the return connecting the newly-discovered offshore wintering grounds for medium-sized (60–300 pounds) bluefin tuna *(Reports of M/V DELAWARE Cruises, Comm. Fish. Rev., 19(5):28–29; 19(8):27–29,* 1957.; *20(7):35–36,* 1958.; *21(4):46–47, 21(7):40–41,* 1959.), with their usual summering area off Cape Cod. Two returns give interesting data on the growth of

Table 1

Tag Returns of Tuna, Marlin and Sailfish Obtained up to January 1, 1960
(Numbers in Parentheses Estimated)

| Species | Date and Locality of | | Years at Large | Size When | |
|---|---|---|---|---|---|
| | Tagging | Recapture | | Tagged | Recaptured |
| Bluefin tuna | July 5, 1954<br>Martha's Vineyard, Mass.<br>(40°54′N-70°45′W) | Aug. 18, 1954<br>Provincetown, Mass.<br>(42°02′N-70°08′W) | 0.1 | 35¾″ | Not reported |
| Bluefin tuna | July 27, 1954<br>Martha's Vineyard, Mass.<br>(41°02N-70°53′W) | Aug. 16, 1959<br>Bay of Biscay<br>(43°55′N-3°25′W) | 5.1 | 28½″ | (150 lbs.) |
| Bluefin tuna | July 25, 1954<br>Martha's Vineyard, Mass.<br>(41°02′N-70°53′W) | July, 1959<br>Bay of Biscay | 5 | 30″ | Not reported |
| Bluefin tuna | Aug. 11, 1957<br>Chatham, Mass.<br>(41°36′N-69°50′W) | Aug. 30, 1959<br>Stellwagen Bank, Mass.<br>(42°26′N-70°24′W) | 2 | (65 lbs.) | 130 lbs. |
| Bluefin tuna | May 24, 1959<br>(38°37′N-68°24′W) | Aug. 20, 1959<br>Provincetown, Mass.<br>(41°58′N-70°13′W) | 0.25 | (150 cms.) | Not reported |
| White marlin | Not reported[1] | April 30, 1957<br>Havana, Cuba<br>(23°10′N-82°20′W) | | Not reported | 60 lbs. |
| White marlin | July 11, 1955<br>Ocean City, Md.<br>(38°05′N-74°35′W) | July 18, 1959<br>Ocean City, Md.<br>(38°05′N-74°35′W) | 4 | (7′2″) | (55 lbs.) |
| Atlantic sailfish | Dec. 15, 1954–Jan. 28, 1955<br>Stuart, Fla.<br>(27°10′N-80°05′W) | Jan. 12, 1956<br>Islamorada, Fla.<br>(24°45′N-80°30′W) | 1 | Not reported | 6′9″ |
| Atlantic sailfish | Jan. 28, 1958<br>Palm Beach, Fla.<br>(26°45′N-79°55′W) | Jan. 14, 1959<br>Stuart, Fla.<br>(27°10′N-80°05′W) | 1 | (7′2″) | 7′2″<br>40 lbs. |
| Atlantic sailfish | Feb. 5, 1958<br>Palm Beach, Fla.<br>(26°45′N-79°55′W) | Apr. 19, 1959<br>Hillsboro Inlet, Fla.<br>(26°15′N-80°00′W) | 1.2 | (7′)<br>(46 lbs.) | 6′11″<br>51½ lbs. |

[1] This tag was issued to a local charter boat at Ocean City, Md., in the summer of 1956. It is highly probable that the fish was tagged there in that summer.

bluefin tuna although, unfortunately, exact size data were obtained at one end of each experiment only.

The returns for marlin and sailfish are of value mainly in showing the survival of the fish and the holding power of the tags. The life span of the sailfish has been reported to be very short (de Sylva, *Bull. Mar. Sci. Gulf and Carib.* 7(*1*):*1–20,* 1957.), and it has been implied that this may also be so for the white marlin (Voss and Robins, *57–15, The Charles F. Johnson Oceanic Gamefish Investigations, Prog. Rept. No. 3, Mar. Lab. Univ. of Miami: 1–11 mimeo,* 1957.). The latter authors also questioned the value of tagging any istiophorids other than very small individuals. Sizes estimated by experienced fishermen indicate that a white marlin which was of average size (7 feet 2 inches) when tagged was not much larger (55 pounds) when recaptured 4 years later. Likewise 2 Atlantic sailfish estimated by an experienced fishing guide to have been about 7 feet long when marked were each recaptured about a year later. These results suggest that the life span of the white marlin may be fairly long, as the species attains weights of over 100 pounds, and that adult Atlantic sailfish may be tagged with a reasonable chance of recapture. The probable movement of a white marlin from off Ocean City, Maryland, to off Habana, Cuba, is of great interest, but due to the unfortunate negligence of the tagger in failing to report the necessary data, this cannot be considered as entirely certain.

This program has been directed by the author under the supervision of William C. Schroeder except during 1956–1957, when Dr. Robert H. Gibbs, Jr., now of Boston University, took over its direction while the author was on leave of absence. The excellent facilities of the Lerner Marine Laboratory were utilized during several field trips to the Bahamas. The valued assistance of these and of the many other individuals who and organizations which have cooperated is most gratefully acknowledged.—FRANK J. MATHER, III, *Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.* Contribution No. 1092. Work supported by grants of the National Science Foundation starting in 1956.

# Herpetological Notes

INTERSPECIFIC HYBRIDIZATION BETWEEN TWO SNAKES OF THE GENUS *ELAPHE.*—Since authentic examples of interspecific hybridization in snakes are still uncommon, this account of a successful mating between a male *Elaphe guttata* and a female *Elaphe obsoleta rossalleni* is being presented.

The *guttata,* which was 142 cm. long at the time of the mating, was hatched in captivity in 1952. The *obsoleta* was bought from a Florida dealer in 1957, at which time she was 137 cm. At the time of the mating she was 152 cm. long. The female was received too late for any breeding activity to be expected in 1957. She was placed in a cage with a male *guttata* in the spring of 1958 and, though no known mating occurred, the male engaged in aggressive courting activity and would pursue the female nearly each time she would move about in the cage. Early in 1959 the female *obsoleta* was placed in a cage with two *guttata,* both large adult males, and the same persistent courting activity took place. This time, however, on the evening of April 22, 1959 the female was observed in coitus with one of the *guttata.* If other matings took place, which is common when snakes are kept together over the entire breeding season as these were, they were not observed.

Beginning June 15 the snake deposited 19 eggs, all normal in size and appearance for eggs of an adult rat snake. The eggs were placed in a wide-mouthed gallon jar, with damp paper towels on the bottom, and placed at room temperature. The lid was generally kept on the jar in such a manner as to permit air to enter; it was opened occasionally to permit evaporation; and water was sprinkled in to wet the towel when indicated. These measures kept the humidity fairly constant as judged by the condensed water on the upper walls of the jar. Two eggs became obviously spoiled and were opened, revealing solidified interiors with no sign of embryos. About 70 days after incubation began, one of the eggs was opened to see if the breeding had been successful, and it was found to contain a fully developed snake ready for hatching. This snake, which was grossly normal, died shortly after being removed from the egg. On September 3, 1959, 80 days after the first one was deposited, several of the eggs were noted to have slits in their shells, and within the following week 14 snakes hatched. One snake died in the egg after

making the slits, and this snake was also grossly normal. The last egg was opened about one week after the last hatching and was found to contain a grossly normal fully-developed but dead snake.

The 14 living snakes in this brood are being raised primarily to see what their adult patterns and colors will be and to find if they in turn are fertile. Consequently, detailed study of them will be done when they die or are preserved, at which time scale counts and other pertinent examinations can be done at leisure. Meanwhile some gross features of the young hybrids are worth mentioning. Since the mother of these hybrids was large enough to be sexually mature when received from the dealer, these young conceivably could be the result of some prior mating. Fortunately, several features about the hatchlings make it obvious that they are hybrids between the species.

Juveniles of *Elaphe* have a disconcerting similarity and some give little or no hint of the colors and patterns of the adult forms. However, some differences between *guttata* and *obsoleta* are readily discernible at hatching and the hybrids show a number of intermediate characteristics. The young of *guttata* and its subspecies have the proximal saddle extending forward to terminate in a bold spear on the head, while the proximal saddle of the *obsoleta* complex terminates in a dual fork farther back on the head. The hybrids are intermediate in this key characteristic, with the proximal blotch extending forward in an irregular or broken spear, in no case as wide or as bold as that of a typical young *guttata*. The band extending across the head anterior to the eyes displays a similar compromise. Conant (1958, A Field Guide to Reptiles and Amphibians of Eastern North America, p. 161) points out the value of the head markings in identifying young rat snakes. In *guttata* the postocular stripe continues onto the neck of the snake while in *obsoleta* it stops at the mouth. In some of the hybrids this stripe stops at the angle of the jaw and in others fragments pick up again on the neck. The saddles of the hybrids are more rounded than those of a comparable-sized *guttata* and, though this is difficult to be certain of in such immature snakes, the blotches of the hybrids do not show the black border seen in *guttata*. The markings on the underside of the hybrids are more like those of *obsoleta* in that they do not meet in the midline or in any case cross to form bands. Though color is not too significant in young *Elaphe* due to the dramatic difference between the young and the adults of a number of the species, the

FIG. 2.—A. Photograph of a typical *Elaphe guttata*, about 2 months after hatching. B. Photograph of a hybrid *guttata* × *obsoleta*, also about 2 months old.

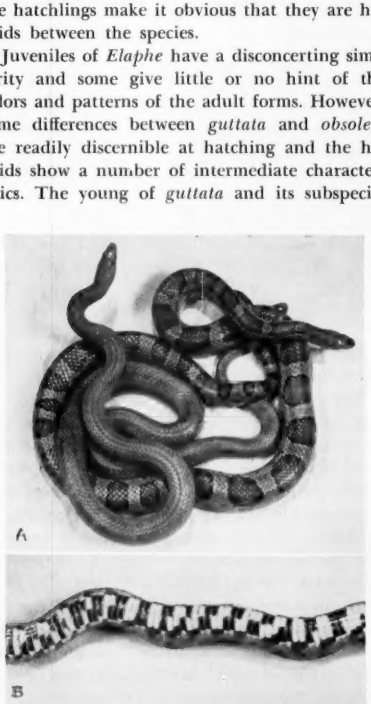


FIG. 1.—A. Adult male *Elaphe guttata guttata* and adult female *Elaphe obsoleta rossalleni*, the parents of the hybrids. B. Underside of a typical juvenile *Elaphe guttata*. C. Underside of a hybrid *guttata* × *obsoleta* also juvenile.

hybrids have dark brown saddles on a generally tan colored background and their abdomens are suffused posteriorly with pink. One peculiarity present in three of the young hybrids tends to indicate a genetic mixup. In two of the young the right eye is abnormal and in the third both eyes are abnormal. The abnormal eyes evidently were arrested in development, being about one third the diameter of normal eyes. They appear to have all the necessary components, differing from normal eyes chiefly in size.

The authors wish to thank Neil D. Richmond of the Carnegie Museum in Pittsburgh, Pa. for suggestions concerning the preparation of this paper.—H. Bernard Bechtel, *164 Plainfield Ave., Johnstown, Pa.* and Joseph Mountain, *101 Clermont St., Johnstown, Pa.*

SOME IRAQ AMPHIBIANS AND REPTILES WITH NOTES ON THEIR FOOD HABITS.—A small collection of amphibians and reptiles was made in Iraq and on Bahrein Island in 1950–52 in connection with general studies of desert life. The cordial interest and assistance of the authorities and students of the College of Arts and Sciences, now Baghdad University, greatly facilitated these studies. The specimens here reported on were sent to the late Karl P. Schmidt of the Chicago Natural History Museum for identification and were retained by the museum.

### Amphibians

*Bufo viridis* Laurenti.—T 1 Pipeline Station, 34°13′N., 41°21′E., 25 June, 1952. One specimen taken in the evening under light in the compound where it was gathering unidentified insects.

*Hyla arborea savignyi* Audouin.—Old irrigation canal north of Falluja, 33°20′N., 44°0′E., 16 April, 1952. This green frog was taken in the company of a ranid in an isolated, shallow pool. The *Hyla* had caught a large Pentatomidae bug, a spider, two ants (*Pheidole* and *Tapinoma*) and fragments of Coleoptera.

A second frog was taken on the open desert in the above area on 23 February, 1951. There was no shelter from plants of any kind. The frog was in the shade of a piece of soil upturned in digging gypsum. The nearest trees and water were more than a mile distant.

### Lizards

*Gymnodactylus kotschyi* Steindachner.—Sersang, northern Iraq, 37°5′N., 43°15′E., 29 July 1952. One dark gray lizard on a large oak tree.

*Gymnodactylus scaber* Heyden.—T 1 Pipeline Station, 34°13′N., 41°21′E, on the Syrian Desert, 24 June 1952. Two specimens, one with two pentatomid bugs, a bee and parts of several ants (*Cataglyphis bicolor orientalis*), and a second filled with indigestible wings of moths, Hemiptera and an Orthopteran. Baghdad, 17 November 1951, in house, one specimen identified.

*Ptyodactylus hasselquisti hasselquisti* Donndorf.—T 1 Pipeline Station, 34°13′N., 41°21′E., 25 June 1952. A gecko from the hills of 1150–1200 feet altitude.

*Hemidactylus turcicus* (Linnaeus).—Baghdad, 8 April 1952, in house. Two specimens identified, one with a large insect, apparently Diptera, and a second with numerous nymph termite remains and a *Pheidole* (?) ant thorax.

*Phyllodactylus elisae* Werner.—Baghdad, 8 April 1952, in house, one specimen identified. This, *Gymnodactylus scaber* and *Hemidactylus turcicus* are among the common house geckoes preying on ants, mosquitoes, roaches and other arthropods.

*Agama caucasica* (Eichwald).—Jebel Hamrin hills at Dyala River, 11 April 1952. One specimen captured was 305 mm. long and was one of two active on sunny surfaces of sandstone outcrops, which at this time (1:30 pm) in bright sun and a breeze were 41.4–47° C. They took refuge in holes in the bare rock when disturbed.

*Agama persica Blanford*—Falluja Desert, 33°20′N., 44°0′E., 20 March 1952. One specimen identified was a more brightly patterned agamid than others of this area and had distinct markings on the underside.

*Agama ruderata* Olivier—Lake Habbaniyah, 23 October 1951; Falluja Desert, 33°20′N., 44°0′E., 2 April 1952. One specimen identified was taken on a windy, desiccating day when the soil surfaces at the time (2:20–3:00 pm) were 42.1–49.6°C.

*Agama pallida* Reuss.—T 1 Pipeline Station, 34°13′N., 41°21′E., on the Syrian Desert, 24 June 1952. One specimen was running on stony soil at 6:00 pm. The stomach contents were badly fragmented but included several unidentifiable orders of insects and the ant, *Cataglyphis bicolor orientalis*.

Falluja Desert, 33°20′N., 44°0′E., 16 October 1951, one specimen identified.

*Agama agilis* Olivier.—Bahrein Island, Persian Gulf, 27 December 1951. A single specimen was taken about 3:00 pm. under a small rock on the windswept, stony desert and was in torpor. After being held in the hand for more than 15 minutes it was still too sluggish to crawl. By 6:45 pm. it had been warmed to activity. This was the coldest season and few insects were active.

*Varanus griseus* (Daudin)—Falluja Desert, 33°-20′N., 44°0′E. 6 May 1952. A female 53.5 cm. long (tail 31 cm.) was pulled from a hole down which it ran. It had many eggs of variable size up to a

small pea. White tapeworms were numerous in the intestine; the stomach contained only grayish unidentifiable material and no arthropods.

*Acanthodactylus* sp.—T 1 Pipeline Station, 34°13′N., 41°21′E., on the Syrian Desert, 24 June 1952. Several specimens were colored exactly as a small locust found here and also like a gray spotted spider from the same stony desert. Taken in small holes in a wadi.

Falluja Desert, 33°20′N., 44°0′E., March 20, 1952. One specimen contained fragments of Coleoptera and ants (*Messor barbarus semirufa*). The lizards were taking refuge in shallow burrows.

Desert at Kerbala, 17 February 1952. Several specimens were taken of which one had parts of seven Lepidoptera larvae, a bee and ants (*Monomorium* sp. and *Messor barbarus semirufa*). A second specimen contained numerous parts of *Monomorium* ants, a male ant, probably *Messor barbarus*, a parasitic Hymenopteran and parts of a spider.

*Ophiops elegans elegans* Menetries—Sersang, Kurdistan, 37°5′N., 43°15′E., 3700 feet. One small lizard on a mountain slope. The stomach contained a leafhopper (Homoptera), a bug (Hemiptera) and a spider. Ash Shafi, 30°46′N., 47°36′E., 25 February 1952. One specimen. The stomach contained remains of midges (Diptera, Nematocera), a leafhopper (Homoptera) and a true bug (Hemiptera). The midges were available here solely because of a total solar eclipse at mid-day when the lizard was taken.

*Eremias brevirostris* Blandford—Bahrein Island, Persian Gulf. 27 December 1951. One specimen taken. The stomach was empty. Desert at Ramadi, 23 March 1952. Four specimens. One stomach with scores of ants (*Monomorium*) and parts and fragments of several other insects; another had a Solpugida, a moth and part of a *Sphingonotus* locust; a third stomach contained parts of a spider, several genera of Hemiptera, a *Sphingonotus*, a Lepidoptera larva and *Monomorium* ants; a fourth stomach contained several spiders, a mantid, a Lepidoptera larva, a weevil and another Coleoptera family and *Monomorium* ants.

Desert at Falluja, 33°20′N., 44°0′E, 24 April 1952. Two specimens. One stomach had a Solpugida and parts of *Monomorium* ants; a second stomach contained one little-digested male *Messor barbarus semirufa* ant, one weevil and five nymph Orthoptera that appeared to be *Sphingonotus*; remains of one Hemiptera were also recognizable.

Desert at Falluja, 33°20′N., 44°0′E, 19 June 1952, one specimen running over 46° C. surface at 9:00 am. The stomach contained a whole roach, part of a scorpion, a winged female *Monomorium* and parts of workers of the same genus, and a *Cardiocondyla* ant.

Desert at Kerbala, 17 February 1952. One specimen. The stomach contained spider parts, two Hemiptera, parts of three *Messor barbarus semirufa* and of five *Cardiocondyla nuda mauretanica* ants.

Lake Habbaniyah hills, 23 October 1951, one specimen, running fast over 38° C. surface (noon) and with tail held high.

This seems to be the commonest lacertid lizard in middle Iraq.

*Ablepharus brandti festae* Peracca.—Baghdad, 7 May 1951. The one specimen identified had parts of four *Pheidole* ants and a much larger Hemiptera.

*Mabuya aurata aurata* (Linnaeus).—Jebel Hamrin (desert hills), 7 May 1952. One specimen, whose stomach contained only a little soil.

*Mabuya aurata septemtaeniata* Reuss.—One lizard taken by Hashim Ali Kazzaz at Kir Bridge, Baghdad, 30 March 1952. The stomach had mostly spider remains and one beetle.

### Snakes

*Coluber ventromaculatus* Gray.—Baghdad, 19 August 1952, in garden. One specimen.

*Eirenis coronella fraseri* Schmidt.—T 1 Pipeline Station, 34°13′N., 41°21′E., on the Syrian Desert, 24 June 1952. One specimen.

*Leptotyphlops macrorhyncus* (Jan.).—Baghdad, 28 April 1952. One specimen in house and a second specimen brought to surface of lawn by flooding.—Neal A. Weber, *Swarthmore College, Swarthmore, Pennsylvania.*

THE WESTERN EXTREMITY OF THE RANGE OF *DASYPELTIS FASCIATA*, WITH NOTES ON ECOLOGY AND COLOR RESEMBLANCE.—The last revision of the genus *Dasypeltis* (Gans, Ann. Mus. Roy. Congo Belge, Sci. Zool, (74):140, 237, 1959) lists the range of *D. fasciata* A. Smith to extend through "lowland rainforest regions of . . . Liberia, Sierra Leone, and Gambia". The Gambia record was based on a single specimen from Cape St. Mary (B.M. 1927-2-2-70). Its base color was a very light tan, much lighter than the olive to chocolate browns of specimens from more eastern localities, and it appeared as if the specimen had faded or been bleached by sunlight. The characteristic *D. fasciata* pattern of blotches was still present.

While the revision was in press I discovered that a partially identified collection in the Carnegie Museum contained another very light colored specimen of this species sent in by F. D. Morrison from Cape Vert, Sénégal, French West

Africa in the summer of 1944. Mr. Morrison (*in litt.*) kindly confirmed that the snake when alive also was a very light rusty brown with faint darker blotches so that "fading" was not involved. The characters of this female specimen (listed as in Gans, *op. cit.*) were: ventrals 252, caudals 69, midbody dorsals 23, head pitted marginally, lateral serration 3, anals serrated, 1 pre- and 2 postoculars, 2 first and 4/3 (left/right) second temporals, 7 upper labials with the third and fourth contacting the eye, body broken. These values fall within the range of variation of data from other Western African specimens of *D. fasciata*.

The more than one hundred mile range extension is of particular interest because of the lack of rainforest on or near Cape Vert. Mr. Morrison informs me that the specimen was collected "in or near a hut in or near the village of Yof, on the northwest side of the Cape" (approx. 17°28'W, 14°47'N). This is a very dry area with only a few scattered baobab trees and no woods or river swamp. Even the forest of Thiés, some 25 miles inland is described as a dryland forest with large and spreading trees, open canopy and some underbrush.

The restriction to a rainforest habitat of more eastern populations of *D. fasciata* appears to be associated with the presence of *D. scabra* (Linné), a distinct species of the open forest and savanna. The western-most record of *D. scabra* is Kouroussa, French Guinea and it is interesting to speculate on the reasons for the absence of this species from the Gambia-Sénégal area. It seems certain that this absence permits the "rainforest species" *D. fasciata* to enter open country in the western part of its range and that the populations that have done so have a much lighter than normal color pattern, providing another instance of the marked color resemblance to substrate in this genus.—CARL GANS, *Department of Biology, The University of Buffalo, Buffalo 14, New York.*

ON THE HEMIPENIS OF THE MOLE SNAKE, *PSEUDASPIS CANA* (LINN).—In a recent note (COPEIA 1959:71–72) I drew attention to a mating between two mole snakes and stated that both four-inch hemipenes were used simultaneously. A photograph was provided. Dr. H. G. Dowling has since pointed out, however, that only one hemipenis was actually involved since the photograph shows the two elongate lobes of a single organ. I am much indebted to Dr. Dowling for drawing attention to the error. Bogert (*Bull. Amer. Mus. Nat. Hist. 77:42*, 1940) has described each hemipenis as extending to the 32nd subcaudal, but bifurcating at the 8th.—C. K. BRAIN, *Department of Lower Vertebrates, Transvaal Museum, Pretoria.*

THE AMERICAN BULLFROG, *RANA CATESBEIANA*, IN JAPAN.—Okada (COPEIA, 1927, No. 158:165) reported that the American Bullfrog, *Rana catesbeiana*, was introduced into Japan by Professor Watase about 1918, and was first propagated at the Imperial University of Tokyo (now Tokyo University). He further stated that the species had multiplied greatly in many places, and that one might eventually expect to find them marketed for food.

During 1958–1959, approximately forty-one years after their introduction, I found bullfrogs to be a well established element of the Japanese herpetofauna. I have seen or collected newly metamorphosed or larval *R. catesbeiana* from the following localities in Honshu: the Tokyo Botanical Garden, Miyogadani, Tokyo (ponds); Mukohara, Yamato-machi, Saitama Prefecture (rice paddy); Arakawa River, 3 to 5 miles NW Yamato-machi, Saitama Prefecture (clay bottomed ponds); Sanjusangendo, Kyoto, Kyoto Prefecture (ponds). On May 23, 1959, at the Tsukiji Fish Market, Tokyo (Japan's largest fish market), I bought an adult *R. catesbeiana* measuring 120 mm. snout-vent length, purportedly from Ibaragi Prefecture, Honshu, for 140 yen (about 40 cents). The dealer had a number of others awaiting sale in a cage.

These observations show that *Rana catesbeiana* has become firmly established in at least the two largest lowland regions of Japan, the Kanto (Tokyo, Saitama and Ibaragi Prefectures) and Kansai (Kyoto Prefecture) Plains. Furthermore, the bullfrog has had bestowed upon it the Japanese common name "shokuyo gaeru"—literally, "food frog". Many Japanese with whom I talked, who had no interest in frogs at all in a biological sense, knew and recognized the "shokuyo gaeru" as an American frog which is a common inhabitant of Japan.

I wish to thank Mr. Charles W. Myers for his suggestions on the preparation of this note.—SAM R. TELFORD, JR., *Florida State Museum and Department of Biology, University of Florida, Gainesville.*

OBSERVATIONS ON A NESTING OF THE WOOD TURTLE, *CLEMMYS INSCULPTA*.—According to Pope (*Turtles of the United States & Canada*, pp. 97, 98, 1949) information on the nesting habits of the wood turtle, *Clemmys insculpta*, are scanty. Laying has been recorded as taking place in the afternoon, during mid-June. The eggs are buried by the female and incubated by the sun. Carr (*Handbook of Turtles*, p. 123, 1952) adds that the incubation period appears to be unknown.

On June 6, 1959 a female wood turtle was found in a suburban back yard in Wood-Ridge,

Bergen Co., N. J. It was placed in the fenced portion of the adjoining yard (an area of approximately 75′ x 30′) where the following observations were made.

On June 12, 1959, the turtle was discovered digging at 8:50 am in a patch of red soil, about 15 feet from the window where we were watching. The morning was cloudy and a fine drizzle was falling. At that time she had already dug a hole perhaps half the depth her hind legs could reach.

Digging continued until 10:24 AM. It was done entirely with the hind feet, which alternated without once missing a turn. After deepening the hole the turtle widened it at the bottom, scraping the right side with her left foot and vice versa. Her head was stretched far out during the digging; front feet were stationary. She dug slowly but did not pause to rest.

At 10:25 AM the first egg was laid. Seven more followed, the last one at 10:34 AM. During laying her head was partly withdrawn, one hind leg rested on the ground, the other at the edge of the hole or just inside. As each egg appeared she raised her rear edge high and lifted her tail. Despite the semicircular pile of dirt behind her we could see clearly as the white and slightly elongated egg was extruded. After the egg dropped, a foot was inserted into the hole but was pulled out at least partly as the next egg appeared. Her hind legs alternated in this action just as in digging.

The turtle rested the next two minutes and then began to fill the nest. Filling and tamping in the original position continued until about 11:20 AM with the turtle pivoting farther and farther to the sides. Then for another 20 minutes tamping and scraping went on, but the turtle moved her front feet from their stations and swung around in an irregular circle that finally brought her some inches away from the nesting site.

The filling action consisted of scratching with toe nails at the sides of the hole, scraping with toes and sides of feet to bring dirt from the surface into the hole, packing with soles of feet flat and alternating rapidly, and tamping with the sides of the feet, back of the feet, and occasionally with the whole edge of the lower leg. She also pounded the dirt with the rear of the plastron until the nesting site was indistinguishable from the surrounding ground. Her head was stretched out during this stage and she rested several times for as long as two to four minutes.

At 11:48 AM the turtle dragged herself onto the brick walk, her hind feet still alternating slowly in scraping motions, but also pushing her forward. Her plastron scraped against the bricks and her front feet seemed to be pushed along too without assisting in walking. By this time the sun was shining bright and hot through thin high haze and the turtle was thoroughly dry. We had noted the location of the nest in relation to nearby plants but also marked it with a ring of pebbles when the turtle was moved.

The turtle was measured on June 15. Her carapace was 6⅝ inches long, 5⅛ inches wide; plastron 6 inches long, 4⅜ inches wide.

On August 29, the nesting site was still intact, with a hard crust on the surface of the soil. At 2 PM on August 30 the nest was empty. That morning a shower had softened the surface and when we examined the site later we found a slot-shaped hole, about ½ inch wide and 1 inch long. Digging down we found a number of pieces of egg shell which were yellowish white and felt rubbery.

A young wood turtle discovered in a neighboring garden on September 12, presumably from this nest, was sooty black in coloration with a sculptured carapace like the adults'; but much flatter. Measurements were: length of carapace 1½ inches, width of carapace 1½ inches, length of tail 1½ inches.—DOROTHY C. PALLAS, *107 Jefferson St., Wood-Ridge, New Jersey.*

NOTES ON LATERAL EXPANSION OF THE PERIPHERY IN JUVENILES OF *STERNOTHAERUS ODORATUS*.—Two clutches of *Sternothaerus odoratus* eggs were made available to me during the summer of 1959, both being collected at Crystal Lake, approximately 2 miles south of Atwood, Kosciusko County, Indiana. Both groups hatched on September 14, 1959.

In an attempt to determine the rate of lateral spreading of the shell, measurements of the young turtles were taken every other day for a period of several weeks after birth. The data (Table 1) support Carr's contention (*Handbook of Turtles*, 1952, p. 84) that "the process may . . . [take] place within no more than a couple of weeks after hatching." The rate is, in fact, more rapid than Carr surmised, almost all expansion was completed within the first week.—KRAIG K. ADLER, *2370 Club Road, Columbus 21, Ohio.*

TABLE 1

AVERAGE LENGTH AND WIDTH OF JUVENILES OF *Sternothaerus odoratus* (in cm.)

| | Clutch A | | Clutch B | |
|---|---|---|---|---|
| | Length | Width | Length | Width |
| Sept. 14 | 1.83 | 1.40 | 2.20 | 1.63 |
| 17 | 1.86 | 1.60 | 2.22 | 1.87 |
| 19 | 1.93 | 1.71 | 2.24 | 1.93 |
| 21 | 1.95 | 1.76 | 2.27 | 2.02 |
| 23 | 1.96 | 1.78 | 2.32 | 2.03 |
| 25 | 1.97 | 1.79 | 2.34 | 2.05 |
| 28 | 1.97 | 1.81 | 2.34 | 2.06 |
| Oct. 14 | 1.99 | 1.82 | 2.37 | 2.09 |

# Reviews and Comments

## Phylax Telescopus—II

One hundred years ago today, press, pulpit and street corner were vocal with discussion of a book recently published by a relatively obscure naturalist whose chief contributions to science had been some geological observations on South America and a monograph on the classification of barnacles. The entire world has lately been celebrating the hundredth anniversary of the publication, on the 24th of November, 1859, of Darwin's *Origin of Species*. Yet we have failed to notice any celebration, even amongst balanologists, of the anniversary of any of Darwin's four erudite and painstakingly done volumes on the Recent and Fossil Cirripedia.

We feel that this discrepancy, in both worldly and scientific approbation, between the reception of two of Darwin's principal works, is illustrative of a fact that is still occasionally lost sight of by modern biologists. We refer to the fact that the most important and lasting part of any man's contribution to human knowledge, be it in systematic biology or experimental physics, is *not* the amount, accuracy, or excellence of observation or experiment that went into it. Rather, it is the penetration, clarity, and breadth of the *ideas* embodied in it and conveyed by it.

For their day, Darwin's barnacle monographs were models of excellence. He himself has told us what difficult labor he put into them—the large amount of material he had to examine, the puzzling over systematic "characters" he had to go through. On the other hand, work on the *Origin* seems to have been comparatively pleasant for Darwin—remembrance of his field observation—culling small bits here and there from other writers—seeing the patterns of relationship throughout all that was known of plants and animals. Yet no specimens that he could examine, no experiments he could have performed, would prove a single thing. The *Origin* was, in essence, purely a work of the mind, a seeing of analogies and patterns. It was, if you will, a work of almost pure speculation! Many of Darwin's scientific contemporaries considered it wildly so.

William James pointed out a long time ago[1] that a principal component of genius is the ability to perceive analogies, to see patterns where other men see only details. Darwin's *Origin* exhibits exactly that type of genius—the seeing of incomplete patterns, in his own work and that of others, with such clarity that he knew they were significant.

We recall hearing one biologist comment on a recent paper by another: "Why, all he did was crib his data from other people! There's no original work in it at all! It's all speculation!" We have even heard it said that our own *Copeia* should print only papers based on "original" data. "Give us good solid papers, Mr. Editor, full of accurate data or thorough experimental results. Those are the ones that really count!"

Are they?

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When an ichthyologist wishes to engage the attention of the public, or even that of his non-ichthyological colleagues, one of the standbys he is most likely to pull out, dust off, and retell is the life story of the eel. Ever since Johannes Schmidt, after years of expeditions and labor, finally considered that he had all the essential parts of the life history of the European and American species of *Anguilla*, and told that story for the first time in 1922, the eel story has been retold in hundreds of books and articles, and in Heaven alone knows how many classrooms and lecture halls. How the two species of eels mature for many years in fresh water, how they both migrate to the same deep-sea breeding grounds southeast of Bermuda, how the leptocephali begin their slow migration back to the continents (one year westward for the American eels, two years eastward for the European), how they turn into elvers and ascend the streams to grow and repeat the process! And how in the *world* do those little eels, in the trackless depths of the Atlantic, know whether they are Europeans or Americans, and what direction to go? In the parlance of the day, the story is a "natural." It has breadth, depth and mystery. Even oceanographers and fishery biologists have used it before Congressional committees to impress legislators who hold the purse-strings.

Now, alas, we have to report the arrival of an iconoclast amidst the eels. Dr. Denys W. Tucker (A new solution to the Atlantic eel problem, 1959, *Nature*, 183: 495–501) of the British Museum, in a brilliant review of the eel problem in the light of much oceanographic data unavailable in Schmidt's day, tells a different story. While we cannot enter into his arguments in detail, Tucker believes that there is only one species of North Atlantic *Anguilla*, and that the slight and overlapping vertebral differences (which alone are said to distinguish the two presumed species; 103–111 for American eels, 110–119 for European)

[1] *The principles of psychology*, 1890. It is interesting to recall that the founder of experimental psychology and the formulator of pragmatic philosophy once collected fishes in the Amazon whilst a student assistant to Louis Agassiz on the Thayer Expedition. And that the earliest scientific work of Sigmund Freund was on the neuroanatomy of lampreys.

are the result, not of species differences, but of different developmental rates caused by temperature differences during early development in water masses of different temperature. Tucker accounts for the delivery of eels with a larger average number of vertebrae on European shores, and of eels with a usually smaller number on American shores, solely by the peculiarities of oceanic circulation.

At present, we do not venture a final opinion on Tucker's thesis. The oceanographic and biological evidence he uses is extensive, and requires a great deal of digesting. We have heard only one adverse opinion on Tucker's remarkable *tour-de-force*, and that was from one of Johannes Schmidt's students, who might, quite pardonably, have felt reason to be critical of such a radical re-interpretation of the eel problem. Our own feeling is that, although attack on Tucker's work may be possible (as our Danish friend has suggested), any complete overthrow of his interpretation can come only as a result of the presentation of new evidence on several critical points, evidence which may be a long time in the gathering. In the meanwhile, ichthyologists had best put the soft-pedal on some of the more intriguing parts of the eel story.

Publication of the great *Fauna of the U.S.S.R.* continues apace. The latest of the fish parts to appear is V. V. Barsukov's account of the Anarhichadidae (1959, *Fauna SSSR, Fishes, 5(5):1–171*, 22 pls.). This, like Svetovidov's accounts of the cods and herrings, is an extensive monograph, covering anatomy, growth, geography and systematics. Barsukov differs from previous workers, including some Russians, in refusing to recognize the genus *Lycichthys* as distinct from *Anarrichas*, and he includes the Pacific wolf-eel in the family, although he sees fit to modify the original and philologically correct double R in *Anarrhichthys* to a single R. Barsukov's paper forms the most extensive study of the wolf-fishes yet made.

Raymond Furon's *Causes de la répartition des êtres vivants—paléogéographie, biogéographie dynamique* (1958, Paris, Masson et Cie: 167 pp.) is designed as a background for biogeographers, by one of the best known geologists in France. Despite the fact that the author's quoted literature sources are (with the exception of publications in geological journals) almost painfully limited to French papers, the book is a good one. It should do much to restrain the more fanciful of European workers on historical biogeography, and may even cause a few of our British colleagues (especially on the botanical side) to pause in their attempt to explain everything by means of continental drift. Moreover, it may serve as a useful introduction to a great deal of French literature not well known to North American biogeographers.

Many ichthyologists who cannot read Russian have wondered about the contents and quality of several Russian text-books on fishes. With the translation into German of G. W. Nikolski's text on fish classification (*Spezielle Fischknude*, 1957, Berlin, Deutscher Verlag der Wissenschaften: xii + 632 pp.), a better idea can be had. The book represents the "special" section (on fish groups and classification) of a two-volume textbook for university students in ichthyology. It takes up the general classification of fishes, but ordinal and familial treatment is usually brief unless the group contains important foodfishes. The bulk of the book is given over to often extensive accounts of the species found in the U.S.S.R. These accounts are undoubtedly useful to the comparatively large number of Russian students who go into work on economically useful fishes. Moreover, due to the comparatively small size of the Russian fresh-water and marine fish fauna, it is possible to include accounts of most of the important species in a book of reasonable size.

The book is well illustrated, even the growth stages of many species being included. Moreover, unlike books by the lower echelon of Soviet writers (who usually credit a copied figure to the first Russian who reproduced it), the real sources of most figures are acknowledged. Even distributional maps of many important families and genera are given.

The literature sources are predominantly Russian, as one would expect of a work written primarily for Russian students of Russian fishes. But the non-Russian references seem often to be arbitrarily chosen, or to reflect special interest in certain areas in Europe and Asia. However, the references do indicate a lack of familiarity with much pertinent work done in the world as a whole.

The general classification adopted is, of course, that of Berg. In one place however, the author has departed from Berg only to make a grave error. In the cyprinodonts, Nikolski has completely misunderstood the close relation of the South American *Tomeurus* to the Poeciliidae, and the obviously direct derivation of the Indian *Horaichthys* from *Oryzias*, and has placed the two Indian and American genera in a special group by themselves. In spite of the striking convergence of *Tomeurus* and *Horaichthys* (and of both with *Phallostethus*!), Nikolski's grouping is completely unnatural.

Although most scientific workers show reasonable gratitude to those who taught them and moulded their ideas, we think it probable that

relatively few fully realize the debt they owe to their teachers, their associates and their colleagues in introducing them into the ways of research and thinking common to the discipline they espouse. Despite the lofty ideals of science, most scientists are not initiators. They are plodders along the well trodden ways of their specialties. Most would never have followed those ways had there not been teachers, associates, and facilities at hand to guide their early steps.

In a land where no teachers, no associates, and no facilities exist for work in a particular discipline, it is only a rare and exceptionally able man who can, single-handed and without encouragement or advice, begin and carry through able research in that discipline. This is why we have such boundless respect and admiration for the late Prof. Alipio de Miranda-Ribeiro of Brazil, one of the truly great figures of South American science. Without even the help of usable literature in his own language, and with no guidance save what he read, he initiated and carried through a notably large amount of respectable and respected research in not one, but four separate zoological disciplines—ichthyology, herpetology, ornithology and mammalogy. At times his foreign (and in later years, his domestic) colleagues criticized details of his work and his ideas, but very few of his detractors had any conception of the breadth of his research outside their specialties or of the discouraging difficulties under which he labored. Probably none of them had as broad a grasp of the vertebrates as a whole. Moreover, in times when most men of his class in Brazil found it easier to make ends meet by holding down several jobs in addition to their government ones, Miranda-Ribeiro decried the practice and stuck resolutely to his professorship in the Museu Nacional, and to the pittance of a salary which was his only income. He was a Brazilian gentlemen of the same school that produced Machado de Assiz. We doubt that there are any now left.

One of Miranda-Ribeiro's minor but vexing difficulties was the near impossibility of finding any publication outlet during the last few years of his life, in the late 1930's. His own institution was in difficulties and could not publish, and other outlets were very few. In this predicament, he and other Brazilian zoologists published a considerable number of papers in a Brazilian farm journal, *O Campo*, which, especially during the years 1937 and 1938, became an important zoological publication. Unfortunately, *O Campo* had almost no circulation outside Brazil, and the stock of back issues was discarded by the publishers before many institutions outside Brazil became aware of their importance. Thus, a number of Miranda-Ribeiro's later papers are difficult to locate in non-Brazilian libraries.

About four years ago, the Museu Nacional in Rio de Janeiro tardily recognized some of the greatness of Miranda-Ribeiro, and issued an imposing quarto memorial volume (1955, *Arquivos do Museu Nacional*, 42(2 parts):1–711, many pls.). The included contributions are by practically every notable living Brazilian zoologist. Bokermann's synopsis of Brazilian *Cycloramphus*, Carvalho's review of the crocodilians of Brazil, Gomes' description of a loricariid catfish, Menezes' list of the common names of fishes in Northeastern Brazil, Paulo de Miranda-Ribeiro's list of his father's type specimens in the Museu Nacional, Travassos' description of a new *Characidium*, and Vanzolini's paper on the distribution and biometry of *Amphisbaena alba* will be of interest to COPEIA readers. However, perhaps the most useful feature of the work is the republication of several of Miranda-Ribeiro's unavailable herpetological and ichthyological papers from *O Campo*. It is a pity all of them were not included. The omitted series on Brazilian zoogeography would have been more valuable than most of the new contributions in the volumes, for they represent a distillation of many years of pondering on distribution patterns in Brazil by a great but singularly isolated zoologist.—GEORGE S. MYERS, *Natural History Museum, Stamford University, Calif.*

BOY'S BOOK OF TURTLES AND LIZARDS. By Percy A. Morris. Pp. vi + 229, 83 figs. The Ronald Press Co., New York, 1959. $4.50.—Mr. Morris has presumably completed his series of books on North American reptiles and amphibians with this third volume on turtles and lizards. He includes most of the turtles, even the sea turtles, and omits only four species of limited distribution. The lizard section is not nearly so comprehensive. It includes 61 species (of which 4 are introduced and one, *Heloderma horridum*, is extralimital) and omits 31 that are listed in the 1953 "Checklist."

Introductory sections for each ordinal group give brief remarks on paleontology, morphology, general habits, and information on care in captivity. These are followed by species accounts that include a statement of range, size, features of identification, habitat, food, and generally something on breeding habits. Remarks on conservation, economic use, and nomenclature are given for some forms. Some of the familial and generic groups (e.g., marine turtles, geckos, spiny lizards) have short introductory sections on general structure and habits.

The photographs, mostly by the author, vary from good to excellent. The text is clear and well

presented. It is remarkably clear of obvious errors, both factual and typographic. I note only *Phrynosoma douglasi* among the latter. Among the former I would merely point out that the really remarkable thing that turtles accomplished was in getting their *pectoral* girdles inside their rib cage (p. 4), question whether bony fishes were really "originally exclusively marine" (p. 4), and warn him on his statement, "all geckos . . . are far too weak to even scratch the skin even if they were to bite . . ." (p. 117). He will undoubtedly get some argument from persons who have been bitten by Tokay geckos (*Gekko gecko*).

All of the above are picayune, of course, The only personal objections I have to the text are what I would consider to be too great a preoccupation with the listing of subspecies, and consequent reduction in natural history information, and in the selection of lizard species—including some introduced and extralimital forms, while omitting such an interesting and unusual form as *Rhineura*, and thus a whole family. I think that Mr. Morris has done an excellent job and personally hope that he writes that book on the care of captive reptiles that is still so badly needed.—H. G. DOWLING, *Department of Reptiles, New York Zoological Park, New York 60, New York.*

RAINBOW TROUT IN MEXICO AND CALIFORNIA WITH NOTES ON THE CUTTHROAT SERIES. By Paul R. Needham and Richard Gard. Univ. Cal. Pub. Zool., 1959. Vol. 67, No. 1, pp. 1–124, plates 1–8, 40 figures, 3 maps. $2.50.—The present student of trout systematics cannot help but think how much easier his task would have been had he been born 100 years earlier. Now he is faced by a welter of hatchery transplants, altered water courses, and the aftermath of contending lumpers and splitters. How much simpler for the 19th century ichthyologist, who could easily have collected large series from natural populations undisturbed by the hand of man!

To the taxonomist of the 21st Century, however, our present position will seem equally enviable. Native trout can still be collected in many places today. The feasibility of making such collections, and their reliability, declines steadily with expanding human activity. Therefore, it behooves the salmonid scientist not to regret the past, but instead to salvage as much as possible for the future.

Needham and Gard's study is a noteworthy contribution in this direction, as it documents collections of trout from the relatively undisturbed southern end of their range. Data on 40 different counts and measurements are presented, based on 306 specimens from 17 localities which extend from northeastern California to southern Durango, Mexico. Details are given for new and previous trout collections in Mexico, supplemented by clear photographs of habitats and of some specimens, as well as by a valuable colour plate of a "Mexican golden trout". Forty half-page figures present statistics for each systematic character. Information is included on some rainbow-cutthroat hybrid experiments, and a number of related topics are discussed.

Interpretations of the interesting morphological differences shown in this study are inevitably controversial. As the authors remark, those characters selected for study are ones liable to considerable direct environmental modification. Moreover, 28 of the characters used are measurements of body parts. These unfortunately have all been converted to proportions of the standard length before graphical presentation. Because there was marked difference between mean lengths of specimens from different localities, many of the striking differences on the graphs may be attributable simply to allometric growth. Comparison of mean length of specimens in each sample with the graphs of morphometric characters, shows in almost half the cases a marked correlation (either positive or negative) between standard length and relative size of the body part. The authors refer in several places to the problems of allometric growth, but do not consistently allow for it in interpreting the data. For example, the average length of fish in their Eagle Lake collection was more than three times the average for the collection with the next largest specimens, and over five times that for the collection with the smallest fish. Not surprisingly, of all 17 collections examined, Eagle Lake fish had the shortest heads, smallest orbits and widest interorbital lengths *when plotted relative to standard length*. The authors comment on the evident allometric growth of these parts, and yet go on to discuss the Eagle Lake fish (p. 31) in terms of the possible adaptive advantages to lake-dwellers of location of the eyes farther back on the head (so as to increase the scope of vision), and the advantages to stream fishes of larger orbits (in securing food and avoiding enemies in waters that are often extremely turbid). (This, by the way, is contrary to the usual observation that fishes adapted to streams have relatively small eyes.) Of the three characters mentioned above in which the Eagle Lake specimens are distinctive in the graphs, two (orbit size and interorbital width) are summarized (p. 79) as being outstanding characters of the population, but the third (head length) is not. Despite their obvious allometric growth, interorbital width and head length are both listed as amongst the best diagnostic char-

acters for general use (p. 33), and are recommended as most worthy of future attention (p. 79); orbit size is not included in these recommendations.

The large Eagle Lake specimens also had relatively short pectoral, pelvic and dorsal fins. The authors again attribute adaptive significance to these characters (lack of currents in a lacustrine habitat (p. 79)), and do not discuss allometric growth as a possible explanation. Yet the dorsal fin, in particular, shows strong evidence of negative allometry (as evidenced by comparing Fig. 19 with the mean specimen sizes given in Table 1). Furthermore, Needham and Gard note that while their Eagle Lake specimens had relatively short fins, Snyder's 1918 description attributes large and strong fins to rainbows from the same lake. Reference to the latter work shows that Snyder's specimens were smaller (approximately 385–423 mm. SL, compared to 424–515 mm. in the present study). Snyder's measurements of fin length on his smaller fish, when converted to proportion of standard length, lie close to the average for all localities in Fig. 19, unlike the aberrant position shown by the mean based on Needham and Gard's large fish from the same lake.

In summary, the conversion of all measurement data to proportion of length, although concise, seems most ill-advised. Some of the resulting differences between sample means may be genotypic and adaptive, while some may be due simply to size differences; the two sources of variability are difficult to resolve in this form of presentation. Some allowance for such obvious allometry seems essential, perhaps through graphical presentation of the raw data on log-log axes, or by correction of measurements for specimen size using a relative growth formula calculated from a single collection having a wide size range. These methods are admittedly cumbersome and not without objections, but the simpler conversion to proportions of standard length regardless of specimen size loses by ambiguity what it gains in conciseness. Wisely, the authors have had their raw data microfilmed and placed in the University of California Library at Berkeley.

Some measured characters (such as adipose fin length) do not apparently suffer from marked allometry, and meristic characters are of course largely free from this source of error. Some of the graphs of these characters in which localities are arranged in order of latitude show signs of a V-shaped cline. The apparent apex of the V is largely suggested, however, by the aberrant counts of the seven collections of "Mexican golden trout" from Verde, Sinaloa and Culiacan river basins. These fish also have distinctive colour patterns, so that the apparent V may be due to a genetically distinct race interposed into a north-south array of otherwise fairly uniform populations. (The southern "normal" appearing rainbows might conceivably be the result of artificial introductions, as rainbow trout from a hatchery near Mexico City are said to have been stocked extensively in surrounding waters.)

In discussing the observed geographic variations, the authors are inclined to stress environmentally-induced differences. They rightly point out, however, that the vertebral differences they have recorded in wild trout are considerably higher than have ever been produced experimentally. Table 10 lists 5 characters (all meristic) whereby the Mexican golden trout differ from others, but it omits reference to the distinctive colour pattern, described elsewhere in the paper, and to the fact that the mean pelvic fin ray counts of all seven collections are slightly lower than those of every other population. There is no evidence for unusual temperature or other environmental conditions in the habitat of the Mexican golden trout compared with trout-inhabited areas immediately to the north and south. The rather distinctive characters of fish in this confined area would therefore seem to be more reasonably attributable to genetic discreteness than to unobserved environmental factors. A similar case could be made for genetic distinctness of the Gila River trout from Diamond Creek, New Mexico, which have unique colouration as well as several distinct morphometric characters, and which were in fact designated as a distinct species *Salmo gilae* by R. R. Miller in 1950.

Regarding nomenclature, Needham and Gard elect to "group the forms studied here provisionally under the single species, *Salmo gairdneri* Richardson, and not, in this paper at least, to recognize formal subspecies." They raise the possibility (p. 73) (although they certainly do not put it forward as a formal proposal) that because of morphological similarity and not-infrequent hybridization, even the cutthroat trout might logically be relegated to a subspecies of *S. gairdneri*.

To this reviewer, there is a happy medium between the taxonomic extremes. Most zoologists accept the failure to successfully interbreed under natural conditions as the best single criterion for recognition of two distinct species. Therefore, because cutthroat and rainbows can usually (although not always) exist sympatrically as good species, they should be so recognized.

Within the rainbow series, the test of sympatry is usually not possible. If two distinctive forms of "rainbow trout" could be shown to exist sympatrically with no interbreeding, they should

probably be designated as distinct species. The usual situation, however, is one of morphologically distinct but allopatric populations. It seems very probable that adjacent pairs of such populations *would* interbreed were the geographic barrier removed. If this be accepted, then the Gila trout, and the Mexican golden trout, should not be rated as species distinct from *S. gairdneri*.

On the other hand, where there is evidence of genetically-determined differences allowing a high proportion of the individuals in a geographically discrete area to be distinguishable from those of another area, then subspecific designation seems desirable. Needham and Gard justifiably point out the absurdity of assigning a name to every phenotypically distinct trout population. There are cases, however, such as the Gila trout, and the Mexican golden trout, (and the coastal as opposed to the Yellowstone cutthroat trouts in the north) where long isolation seems to have resulted in genotypically distinctive, and visibly distinguishable, races. These races can be designated as formal subspecies both properly and usefully. Needham and Gard's data could well be interpreted (laying more stress on colour pattern, and less on body proportions subject to allometric growth, than did the authors) as indicating the presence of three subspecies of rainbow trout amongst the samples they studied.

There will inevitably be disagreement amongst specialists on the interpretation of Needham and Gard's material. There will be no disagreement, however, concerning the energy and initiative they have displayed in assembling and presenting a wealth of data from one of the more inaccessible strongholds of the trout.—C. C. LINDSEY, *Institute of Fisheries, University of British Columbia, Vancouver, Canada.*

ALL ABOUT TROPICAL FISH. By Derek McInerny and Geoffrey Girard. The Macmillan Co., New York and London, 1958: 480 pp. $15.—This is one of the larger books on tropical aquarium fish keeping, done more or less in the style of the well-known book by W. T. Innes, to which the majority of works in English on the same subject owe so much—even to the point of copying illustrations. The present book is refreshing in that its photographic illustrations, over 100 of them in color, are all original, being the work of a rare and excellent fish portraitist, Brian Barratt. The color photos appear to be reproduced by an offset process, which at times gives a wonderfully rich natural tonal effect, at others unfortunately modifies the colors. In most instances the finer details are blurred. In the black-and-white photos, the offset reproduction is almost uniformly bad.

For the average aquarist, the text is adequate, having the usual directions on how to do or not to do things properly presented in a better-than-average mannner, for the senior author is an experienced aquarist and fish breeder. An innovation is the summarized section on breeding each species of which the breeding habits are known. However, the authors would have done well to have an ichthyologist correct the names and identifications. A few species are badly misidentified, and a number of scientific names are misspelled. The price of the book is high in comparison to competing works.—GEORGE S. MYERS, *Natural History Museum, Stanford University, California.*

POISONOUS AMPHIBIANS AND REPTILES. RECOGNITION AND BITE TREATMENT. By Floyd Boys and Hobart M. Smith. Charles C. Thomas, Publisher; Springfield, Illinois. xiii + 149 pp., 30 figs., 1959. $4.75.—This unpretentious little volume, a collaboration by a physician and well-known herpetologist, is an attractive, extremely readable book. Its greatest appeal lies in its bringing together bits of scattered information from many different sources and in its simple, lucid, and direct presentation. Scientific names are assiduously avoided, medical terminology is translated into lay language, and instructions are explicit and even somewhat repetitious. The result is a summary of the subject that can be read at one sitting by persons of widely different backgrounds and one that impresses the material on the reader in such a way that a surprising amount of information is retained after a single reading.

Part 1 is a brief introduction and an outline of the occurrence of venomous animals by taxonomic group. Parts 2 through 4 survey animal venoms found in the amphibians, the turtles (*Amanita* poison ingested by box turtles), and the lizards (Gila monster). Part 5, the longest chapter, presents general information on snakes, including brief discussions of general characteristics (structure, habits, erroneous beliefs, etc.), the types of venomous snakes, methods of envenomation, composition of venoms and response of victim to different kinds of bites, and factors affecting potency of venom and seriousness of the bite. Part 6 deals with precautions that can be taken to prevent snakebite and suggestions for preparedness such as availability of snakebite kits. Part 7 concerns distinguishing venomous from harmless snakes and means by which the bite of a poisonous species can be distinguished from that of a non-poisonous species. Part 8 recommends first aid measures for bites of both venomous and harmless snakes and lists the "do" and "do not" aspects in the event of bite by a poisonous snake. The first part of this chapter is excellent; the latter

part, entitled "Recommended general first aid procedure in specific case situations" is a bit superfluous. Part 9, the second largest section, covers medical treatment and contains additional discussion of diagnosing bites, general recommendations, first aid measures as well as comments on the value of antivenins and an evaluation of clinical methods and various drugs and their benefits to the patient. A partially annotated bibliography of 73 titles covers the most important literature on the subject treated in the book, and a postscript expresses concern with the growing quantity of literature that denies the value of the mechanical mode of treatment.

Mechanically, the book by Boys and Smith is good and the only criticisms worth mentioning are the too-frequent use of italics and large caps to lend emphasis (with the result that emphasis is actually lost) and the unfortunate change in font on one or two pages. Editorially, it may annoy some readers because of the constant use of the noun "first aider," and its reference to "red-colored" and "red-legged" frogs in the chapter on amphibians will puzzle herpetologists unless they know that the species referred to are *Rana palustris* and *Rana boylii*. Perhaps the most disappointing feature to one who wishes a summary of venoms and their treatment is the bare mention of cryotherapy and then its dismissal from further consideration. This controversial method of treatment would seem to deserve at least a brief reiteration of the evidence for and against it.

The care exercised by the authors to speak in plain language understandable to persons with varying amounts of training is extremely commendable. Two figures are exceptionally instructive and deserve special comment. Fig. 15 is a map of the United States showing the number of poisonous species of snakes at any given locality by use of different zip-a-tone patterns, and Fig. 16 is a clever diagrammatic representation illustrating the difference in sequence of colors on coral snakes and the harmless snakes superficially similar to coral snakes. The authors have done a good job in selecting, summarizing, and organizing information on poisonous amphibians and reptiles. In fact, there is no other single source for the information presented; and for this reason alone their book is a valuable addition to the library of herpetologist, physician, sportsman, those who have a desire to be well-versed in first aid, and the myriad of other people whose duties or pleasures take them out-of-doors in areas where poisonous animals may be encountered.—PHILIP W. SMITH, *Illinois Natural History Survey, Urbana, Illinois.*

A LABORATORY MANUAL OF *CRYPTOBRANCHUS ALLEGANIENSIS* DAUDIN. By Hazel Elisabeth Branch. Vantage Press, [1959]: 79 pp., 5 pl. $2.95.—This is a second edition, "revised, though not extensively," of a manual apparently originally published in 1935. Bibliographers will be annoyed, and quite properly so, by the fact that no publication date appears in the present edition. The book is arranged in the classical form, with a section each devoted to external features, skeleton, musculature, viscera, vascular system, and nervous system. Explicit directions for step-by-step dissection are given, and these are said to have been tested on several generations of students. Crude, but reasonably adequate, drawings illustrate various features of the anatomy. I find it disturbing to find the student instructed to clean the skeleton of his specimen in Chapter II, and then to proceed with the dissection in Chapter IV. There is a bibliography of thirty three titles, several of which would certainly be unavailable to the student and including two papers in Dutch! It is incredible that the standard reference work on salamander anatomy, Francis' *The Anatomy of the Salamander*, which should be available in every college library, is not listed. I cannot believe that this book seriously threatens the position of primacy long held by *Necturus* in college courses in comparative anatomy.—D. DWIGHT DAVIS, *Chicago Natural History Museum.*

AMPHIBIA. *Zoological Record*, Vol. 93, Sec. 16A, 1956:106 pp. Compiled by A. G. C. Grandison (Recent) and W. E. Swinton (Fossil). Zool. Soc. London, 1959. Six shillings.—The *Zoological Record* in its various sections is the strongest bibliographic tool of most zoologists. The present section is, despite its tardy publication, a boon to those working with amphibians from any standpoint. As usual, an alphabetic author index provides titles and citations to the papers cross-referenced in subject and systematic indexes.

Scrutiny of the *Record* shows what may be suspected: that the preponderance of papers of a distributional and systematic nature was by North Americans and pertained to their continent, that neglect of the great tropical faunas is evident, and that the majority of foreign language papers was concerned with problems other than systematic or ecological. Inspection also leads to the inference that those who regard the present *Zoological Record* as solely or primarily a taxonomists' tool are mistaken.

A more quantitative analysis reveals further points of interest. There are 740 titles listed, and of these, *40 per cent* were in languages other than English. The three principal foreign languages were French, Italian, and German—80 to 90 papers appeared in each. The remaining 15 per cent of the foreign language papers were in Russian,

Spanish, Portugese, and various Slavic and Scandinavian languages. No papers originally in Chinese or Japanese were noted. The high proportion of papers in Italian is not due to numerous contributions by a few authors and is thus all the more surprising. It is speculative to say much about differential coverage, but papers in English, and perhaps Spanish and Portugese, seem proportionately less well represented than those in the principal foreign languages. However, even in the probably well covered Italian language literature at least three 1956 papers were missed. In this connection, the delay in relatively complete coverage should be noted: of the 740 titles, one-fourth were published prior to 1956 (chiefly in 1955). That this is true of 1956 literature is apparent from a survey of 1956 papers dealing with amphibians that were recorded in *Biological Abstracts* up to mid-1958. Only about 180 abstracts were found, and one-third of these were of the papers in COPEIA (16) and *Herpetologica* (41). Yet 41 of the papers were not in the *Zoological Record*! Some of these omissions were surprising. They included one paper in *Science*, one in *Herpetologica*, and several by authors who had other titles in the *Record*. Even the rather small literature on fossils had gaps, for papers by two prominent paleontologists were not listed. It seems clear that there is a serious lag beyond that of delay in publication and that thorough checking of abstracting publications would eliminate a substantial part of it.

The compilation itself appears generally well done with respect to the author and systematic indexes. The subject index could stand thoughtful improvement. Many subcategories containing one or two papers could well be placed in larger subcategories that adequately indicate the nature of the material. References are apt to be overlooked by people who come upon the larger appropriately named subcategory first. However, major revision of the subject index should be careful and lasting since it is troublesome when searching a particular subject to have the subject's classification change from one volume to the next.

In sum, the present section of the *Zoological Record* is a splendid effort as regards both subject and language coverage and the compilers deserve commendation. Nevertheless, coverage can obviously be improved. Readers can help by sending copies of their papers to the editor of the *Record*. They can help further by urging colleagues in such fields as physiology and experimental embryology to do likewise. And of course they can help themselves, such colleagues, and the *Zoological Record* by making the inexpensive purchases of the sections of personal interest and using them. That the latter is advisable is suggested by the humbling fact that less than 3 per cent of the 1956 world literature on amphibians was published in the journal COPEIA.—GEORGE B. RABB, *Chicago Zoological Park, Brookfield, Illinois.*

# EDITORIAL NOTES AND NEWS

**Recent Deaths** BELA HANKO, Toronto, Canada; 72; zoologist in the fisheries library of the department of zoology at the University of Toronto; formerly first director of the Hungarian Biological Institute in Tihany and a member of the Hungarian Scientific Academy; 16 Nov. PAUL S. WELCH, Professor Emeritus of Zoology, The University of Michigan. RICHARD B. MILLER, Department of Zoology, University of Alberta, Alberta, Canada.

**Foreign News** SOCIEDAD SUDAMERICANA DE HERPETOLOGIA. The development of herpetological study in South America during the last 20 years, and the number of official scientific centers applied to this branch of zoology justify the coordination and the stimulus to be derived from the creation of a "gran sociedad continental" which is capable of promoting interchange, reunions and publications, programs of papers and international relations. Particularly in Argentina, Brazil, Chile and Uruguay many papers have had as their subject the varied world—in this little known region—of batrachians and reptiles. There exist internationally recognized centers such as Butantan of São Paulo, the Instituto Malbran of Buenos Aires, the Museo Nacional de Rio and the Museo de la Plata.

The ideal model which we have held as a guide has been the A.S.I.H., and its many activities.

The general basis of the project and its approval was obtained in discussions during the First South American Congress of Zoology in La Plata in October 1959. Having founded the Society, a more difficult and longer period will ensue while studying its immediate development and structure. This will be especially difficult owing to its continental character embracing twelve distinct countries, with distinct idiosyncrasies and organizations, and at times with the difficulties of rapid communication and facile reunions.

The enthusiasm aroused by this initiative suggests that the venture will prosper and the new organization will be an element of progress in the knowledge of this area and may serve as an instrument of collaboration and of bringing together panamerican culture. DR. JOSE M. CEI, *Secretario Provisional de la SSH, Director, Instituto de Biologia, Facultad de Ciencias Medicas, Universidad Nacional de Cuyo, Mendoza, Argentina.* Translated from the Spanish by N. ROTHMAN, Philadelphia Herpetological Society.

The all-India Congress of Zoology, sponsored by the Zoological Society of India, met at the University of Jabalpur during October 24–28, 1959. The president, DR. M. L. ROONWAL, director of the Zoological Survey of India, referred in his address to the great number of species comprising the fauna of India and pointed out how little is known of the biology of many of even the commoner ones. He concluded with a plea for the training of more systematists to work on the national zoological collections in the charge of the Zoological Survey of India. The Congress which followed was divided into six sections at which more than a hundred papers were presented, and symposia on marine zoology and fishes in the Indian Ocean and on the re-orientation of teaching of zoology in India were held.

Foreign Colleagues Travel. DR. W. HELLMICH, Zoologische Staatssamlung, Munich, is making a trip to East Africa that will take him to Ruanda Urundi, Kenya, Tanganyika, and Ethiopia.

MR. CHIN PHUI KONG, Fisheries Officer, Agriculture Department, Colony of North Borneo, is spending six months at Chicago Natural History Museum working on fresh-water fishes of North Borneo with DR. ROBERT F. INGER.

DR. ENRICO TORTONESE, Director of the Museo Civico in Genoa, was at the Marine Laboratory of Miami University during the month of April.

A.S.I.H. Members Overseas. PROFESSOR G. S. MYERS was again able to visit Colombia in February of 1960, and to collaborate with GENERAL THOMAS D. WHITE, Chief of Staff, U. S. Air Force, and LEE WULFF, well known fish and game writer and photographer of Shushan, New York, in obtaining collections of Colombian fresh-water fishes. They also visited the Instituto de Ciencias Naturales in Bogota and conferred with DR. FRED MEDER, herpetologist, and PROFESSOR GEORGE DAHL, ichthyologist of the Instituto, on ichthyological and herpetological matters.

Late in March, PROFESSOR AND MRS. G. S. MYERS left on a six-months' trip to examine zeomorph fishes in European museums. They will be at the British Museum (Natural History) during July and August and will return to Stanford late in September.

PROFESSOR R. L. BOLIN of Stanford's Hopkins Marine Station spent January, February and March, 1960, as leader of the Cooperative Marine Survey of the Gulf of Thailand, under the joint sponsorship of the Thai government, Scripps Institution of Oceanography, and Stanford. PROFESSOR BOLIN took the place of DR. ANTON BRUUN of Copenhagen, whose unfortunate illness has prevented his presence in Thailand. Two members of the George Vanderbilt Foundation at Stanford, DR. ROFEN and DR. FEHLMANN, expect to begin the shore work of the Survey this Autumn.

**Publication News** *THE origin of snakes* (1951, Biol. Rev. Cambridge Philosoph. Soc., 26 (2):193–237). by A. D'A. BELLAIRS AND GARTH UNDERWOOD, has again been reprinted and may be obtained at cost plus mailing charges. Postpaid prices of this 44-page article are as follows: 1 copy, $0.50; 2, $0.96; 3, $1.39; 4, $1.81; 5, $2.24; 6, $2.72; 7, $3.15; 8, $3.57; 9, $4.00; 10, $4.42. Since these reprints are being sold at cost, payment must accompany each order; billings cannot be made. Orders should be sent to the *Division of Reptiles and Amphibians, Museum of Zoology, The University of Michigan, Ann Arbor, Michigan.*

New Journal.—*The Occasional Papers of the C. C. Adams Center for Ecological Studies,* the first number of which will appear in late 1959 or early 1960, is a new publication series for the Mid-western United States. Those interested in being placed on the mailing list should write to THANE S. ROBINSON, director, *C. C. Adams Center for Ecological Studies, Western Michigan University, Kalamazoo, Michigan.*

Biological handbooks.—The Federation of American Societies for Experimental Biology, Washington, D. C., has been awarded a two-year grant by the National Science Foundation for partial support of the Office of Biological Handbooks, which is operating at the federation headquarters under the direction of PHILIP L. ALTMAN. Other agencies supporting the Office of Biological Handbooks are the National Institutes of Health and the Department of the Air Force.

Translations.—The AIBS Committee on Trans-

lations had its first meeting in the AIBS offices December 8, 1959. Dr. Fred R. Cagle, Chairman of the Committee, indicated that though the primary concern would be with translations, the committee must ultimately consider the whole area of difficulty of exchange of biological information between countries where there is a language barrier. Ways of cutting publication costs were discussed, as well as the problem of making the availability of the translations known to interested scientists. The committee hopes to increase the number of biological fields represented by translations, and to interest other scientific groups in discussing and making recommendations about the program.

Members of the committee include: Dr. Donald P. DeSylva, Dr. Foster E. Morhardt, Dr. Kenneth C. Kates, Dr. Wilbur B. Quay, and Dr. Chauncey Leake. Also attending the meeting were Mr. Scott Adams and Mr. Paul Feinstein of the Office of Science Information Service of the National Science Foundation, Dr. Hiden T. Cox, Executive Director of AIBS, Mr. Francis C. Harwood AIBS Director of Publications, and Mr. Harlod Osborne, Director of the Biology News Bureau. The Committee also met in January 1960.

Hydrobiology Directory.—Dr. Robert W. Hiatt, Dean and Director of Research of the University of Hawaii has begun the revision of the present Hydrobiology Directory. The new Directory will be international in coverage and will include all existing marine and freshwater facilities insofar as possible. Publication is anticipated in December, 1960. This revision is sponsored by the ONR.

Books on Zoology.—A supplement to the booklet "Books on Zoology" is now available. It lists 200 zoology books published since June, 1958. The supplement is free and may be obtained from the *Society of Systematic Zoology, Department of Zoology, Southern Illinois University, Carbondale, Illinois.*

Reprints of certain papers on vertebrates which have appeared in the *American Midland Naturalist* are available for a nominal handling and mailing charge. A list of available reprints may be obtained writing *The American Midland Naturalist, University of Notre Dame, Notre Dame, Indiana.*

**Biological Institutions**

THE *Woods Hole Oceanographic Institution* is proceeding with its plans for the design and construction of an oceanographic research vessel. Funds for the purpose have been made available by the National Science Foundation. According to present plans, the total complement of the ship will be 39 men, of whom 15 to 19 will be members of the scientific party. The ship, of about 1000 tons, will be approximately 175 feet long and will have a cruising radius of about 7000 miles. At present, it appears probable that 50 per cent of the total area of the ship will be reserved for the scientists. This will include deck areas, laboratory space, and living quarters. The other 50 per cent will be used for ship operations, crew quarters, mess halls, and so forth. Preliminary plans call for about 1700 square feet of space for enclosed laboratories. A chemistry-laboratory type bench will be installed, with vacuum lines and supplies of gas, compressed air, nitrogen or other tank gas, and fresh and salt water. About 3000 square feet of open deck will be used for scientific purposes. The main after deck will accommodate the large nets and trawls. One laboratory will be provided with running-sea-water aquaria. At present, installation of six aquaria, each about 3 by 3 by 4 feet, with individual temperature control, is contemplated. The organisms collected could thus be maintained at the temperature of their natural habitat. A walk-in deepfreeze for scientific purposes will be provided. This will be ample in size to freeze large fish and will provide storage space for large numbers of samples frozen for preservation or for chemical analysis. One section will be for quick freezing. The bow may be made bulbous, with underwater observation ports and space for two observers. The ports would be 10 to 12 feet below the water line and should provide a good opportunity to observe fish and their behavior and, possibly, a means of observing equipment in operation under water. The ship is intended to be the best oceanographic vessel afloat, providing facilities for as broad and complete a program as possible. Suggestions which will help in achieving this aim will be most welcome. Comments concerning requirements for biological facilities for this ship should be sent to Bostwick H. Ketchum or Frank Minot, both of the *Woods Hole Oceanographic Institution.*

*The Narragansett Marine Laboratory* of the University of Rhode Island at Kingston, reports the following additions to its staff: Professor of Biological Oceanography and Dean of the Summer Session, Dr. Nelson Marshall, formerly Dean of Liberal Arts at Alfred University; Dr. Harry P. Jeffries, formerly of Rutgers University, now Associate Oceanographer and Assistant Professor of Biological Oceanography; Assistant Biological Oceanographer, Theodor J. Smayda, who recently returned from four years' graduate study at the University of Oslo, Norway.

*The Highlands Biological Station,* located in

the Southern Appalachians at Highlands, North Carolina, near the South Carolina and Georgia boundary lines, has received a grant from the National Science Foundation to award grants-in-aid to competent investigators for biological research during the summer of 1960. Awards were made about mid-March, 1960, to applicants whose research must be concerned with the biota of the Southern Appalachians. Investigations involve a variety of biological fields. For detailed information and application blanks write to the Executive Director, Highlands Biological Station, Highlands, N. C.

*The Oceanographic Laboratory* of the Randolph High School, Randolph, Massachusetts, is an ambitious effort to familiarize outstanding teen-agers with research methods and problems associated with fishery biology and oceanography. Some active projects underway include: a tagging study of the Atlantic cod, *Gadus morhua*; a study of the infestation pattern of attached parasites to serve as natural tags in order to outline the distribution pattern of haddock, *Melanogrammus aeglefinus*; determination of the food habits of the winter flounder, *Pseudopleuronectes americanus*, the Atlantic tomcod, *Microgadus tomcod*, and the Atlantic cod. While some fish are being collected by handlines from the Laboratory's 16-foot, 18-horsepower motorboat, others are being collected from cooperative fishermen in the local ports of Boston, Cohasset, Scituate, and Hull. Fecundity, age and growth, plankton, and hydrographic studies are also being carried out. The work is under the direction of high school biology teachers. For further information concerning this unique experiment in teaching, contact KENNETH SHERMAN, Randolph High School, Randolph, Massachusetts.

*The Friday Harbor Laboratories* of the University of Washington, located on San Juan Island approximately 80 miles from the Seattle campus, has announced the program for summer, 1960. Formal courses, seminars, and opportunity for directed or independent research, are the primary activities outlined. Two terms of formal courses are planned: first term—subjects include: oceanographic meteorology, ecology of zooplankton, marine invertebrate zoology, and invertebrate embryology; and second term—continuation of the meteorology and invertebrate zoology courses, with the addition of ecology of phytoplankton and problems of fish biology. The latter course is taught by DR. C. J. D. BROWN. The laboratories provide well-equipped facilities for graduate students and independent investigators in the marine sciences. For bulletin and application forms, address: Director, Friday Harbor Laboratories, Department of Zoology, University of Washington, Seattle 5, Washington.

*Southwest Research Station.* Institute in Techniques and Methods in Field Geology and Field Zoology will be conducted by the Department of Public Instruction of the American Museum of Natural History at the Museum's Southwestern Research Station in Portal, Arizona from July 5 through August 2, 1960. Further information may be obtained from: C. BRUCE HUNTER, Director, Summer Institute in Field Geology and Field Zoology; the American Museum of Natural History, 79th Street and Central Park West, New York 24, New York.

*The Steinhart Aquarium.* The final plans and specifications for the rehabilitation of Steinhart Aquarium were completed during May, 1960, work being scheduled to get under way by June of this same year. Eighteen months of time will be involved in the reconstruction, at the end of which time the refurbished Aquarium will boast of totally inert water systems for the first time in its existence. The range in tank sizes will be from 25 gallons to 63,000 gallons. A new pipe line to the ocean will complete the final needs for the institution.

**Meeting Western Division**

THE Western division of the *American Society of Ichthyologists and Herpetologists* will hold its 1960 meeting in conjunction with the Pacific Division of the American Association for the Advancement of Science at Eugene, Oregon, during the week of June 13–18. According to present plans the meetings, including joint sessions with the Herpetologists' League, will be scheduled for Monday and Tuesday, June 13 and 14, with both morning and afternoon sessions for submitted papers and a business meeting Tuesday afternoon. Additional information can be obtained from DR. A. E. LEVITON, *California Academy of Sciences, San Francisco 18, California.*

**San Francisco Bay Area Herpetological Activities**

HERPETOLOGISTS (and their wives) residing in the San Francisco Bay area met at the California Academy of Sciences, January 9, 1960 to examine the new facilities of the Academy's Department of Herpetology and for a general review of current herpetological activities at local institutions. Those in attendance included staff and students from the Berkeley Campus of the University of California, Stanford University, San Francisco State College, Modesto College, Menlo College, and the California Academy of Sciences.

From the Berkeley Campus of the University

of California the following activities were reported on: Dr. Robert C. Stebbins recently returned from a year's trip to South Africa where he investigated the pineal eye in Triassic mammal-like reptiles in a continuation of his studies on the evolution of the pineal apparatus. In addition, Dr. Stebbins is collaborating with Dr. Alden Miller, also of the Berkeley Campus, in a study of the vertebrates of Joshua Tree National Monument, California. James D. Anderson is working under Dr. Stebbins on his doctorate thesis, a comparative ecology of coastal and montane populations of *Ambystoma macrodactylum*; he is also continuing a study of the amphibians and reptiles of Sierra del Nido, Chihuahua, Mexico. Next fall, Anderson will assume teaching duties at Rutgers University. Sam McGinnis is doing a masters dissertation on the affects of the parietal eye upon temperature regulation in lizards. Daniel Wilhoft, who is also working under Dr Stebbins, is spending a year in Australia on a pre-doctoral Fulbright fellowship where he is studying thyroid activity in tropical lizards. Dr. Robert Glaser, who completed his Ph.D. degree last year under Dr. Stebbins, received a post-doctoral fellowship from the National Institute of Health for work at the University of California on the influence of the parietal eye and psychopharmacologic agents on locomotor activity in lizards.

Dr George S. Myers of Stanford University is devoting himself primarily to ichthyological work having received a three-year National Science Foundation grant for a study of the deep-sea fishes of the Order Zeomorphi. He is, however, completing several short papers on South American amphibians in collaboration with Dr. Leviton, who recently received his Ph.D. under Dr. Myers' sponsorship. Graduate students in herpetology working under Dr. Myers include: Angel C. Alcala, an instructor at Silliman University, Dumaguete, Philippines, who has completed his masters thesis on the life-histories of some frogs occurring on Negros Island, Philippine Islands; Harold E. Munsterman, who is continuing his studies on the snakes of the Ryu Kyu Islands; and Benjamin H. Banta, presently at Pomona College, who is completing his Ph.D. dissertation on the systematics and ecology of Great Basin reptiles. Dr. Walter C. Brown of Menlo College, and a Research Associate at Stanford University, is continuing his studies on the ecology and zoogeography of Philippine reptiles and amphibians.

At the California Academy of Sciences the Department of Herpetology has moved into new quarters, which include new offices and laboratories and a new room (including appropriate shelving!) to house the 100,000 specimen alcohol collection. Dr. Alan E. Leviton, Assistant Curator (in charge), is preparing his manuscript on the systematics and zoogeography of Philippine snakes for publication and is continuing his studies on the systematics of Asian snakes. Dr. Leviton and Dr. Myers, who was recently appointed a Research Associate in the Academy's Department of Herpetology, are completing their basic introductory bibliography of world-wide herpetology. Dr. Anatole S. Loukashkin, the Academy's expert on the natural history of Manchuria and adjacent regions of the Soviet Union, and Leviton are preparing a translation of Dr. P. V. Terentjev's history of Russian herpetology which will include, through the kindness of Dr. Terentjev, a complete bibliography of Soviet herpetological literature. Dr. Earl S. Herald, director of the Academy's Steinhart Aquarium is busy planning to spend recently voted bond-issue money to renovate the Aquarium. Included in his plans will be an expansion of the already excellent herpetological exhibits.

At San Francisco State College Dr. James P. Mackey is studying the intraspecific variation in *Hyla regilla*, and Dr. Lawrence W. Swan is continuing his studies on high altitude ecology of reptiles and amphibians in southeastern Asia. In the Department of Anatomy, University of California School of Medicine, Dr. Malcolm R. Miller is proceeding with his investigations on carbohydrate metabolism in reptiles and amphibians. And Dr. Nathan W. Cohen of Modesto Junior College is continuing his work on color photography of amphibians and reptiles.

Others in attendance at the January meeting included: Dr. Robert C. Miller, Director of the California Academy of Sciences; John H. Larsen, Jr., who is taking his Ph.D. work in herpetology (a study of the cranial osteology of neotenic salamanders) under Dr. Richard C. Snyder at the University of Washington; John F. Lawrence, curatorial assistant in herpetology at the University of California (Berkeley Campus); and John S. Applegarth, who is completing his A.B. degree in biology at Stanford University.

**Stanford**

FOUR students are completing their work for the doctorate in the Spring and Summer of 1960. Dr. Stanley H. Weitzman (Studies on the Classification and Osteology of Characid fishes), is now Instructor in the Department of Anatomy, Stanford Medical School, and has begun an investigation of senescence in annual cyprinodont fishes. Dr. Alan E. Leviton (Monograph on the Snakes of the Philippines), has been appointed Curator of Herpetology in the Cali-

fornia Academy of Sciences, San Francisco. Dr. Adair Fehlmann (Ecology of the Fishes in a Tropical Stream in the Palau Islands), remains as Assistant Director in the George Vanderbilt Foundation at Stanford. Dr. Warren Freihofer (Neurological Evidence for Relationships Among Percomorph Fishes) has accepted a temporary position at Stanford under an NSF grant for general curatorial work. Howard McCully (Scale Structure in Serranid and Related Fishes), and Benjamin Banta (Ecology of Lizards in the Great Basin) expect to complete the doctorate within the year. Several new graduate students in ichthyology and herpetology will begin work with Professor Myers in October.

Hugh DeWitt and James Tyler have completed study of a collection of Antarctic fishes obtained as part of their work in Antarctica during the International Geophysical Year. Professor Wohlschlag is continuing, from Stanford, to direct the outfitting of the biological laboratory being set up at McMurdo Sound, and will go again to the Antarctic late in 1960 to continue ecological work on the fishes.

Dr. Walter C. Brown, Research Associate in Herpetology at Stanford University, is continuing work on the reptiles and amphibians of the Islands of Negros and Mindanao at Stanford. Mr. Angel C. Alcala, of Silliman University, Dumaguete, Philippines, who has been associated with Dr. Brown in the work, spent the school year of 1959–60 at Stanford and has obtained the A.M. degree, his thesis having been concerned with the life-histories of Negros Island amphibians.

Professor Victor C. Twitty, Chairman of the Biology Department at Stanford, is continuing his extensive program of research on the hybridization and population biology of newts of the genus *Taricha*. He reported on some of his results in an article entitled *Migration and speciation in newts*, in *Science* for Dec. 25, 1959.

**Southern California University of**

THE Department of Biology at the University of Southern California is continuing in its expansion of a vertebrate biology program. Dr. Jay M. Savage and Dr. Andrew Starrett are responsible for direction of the program. The following students are engaged in work toward advanced degrees with specialization in herpetology or ichthyology. Anthony J. Gaudin is engaged in a comparative study of life history, development and behavior in *Hyla regilla* and California *Hyla arenicolor* for his master's thesis. Shelly R. Johnson continues his analysis of the life history and behavior of chuckwallas, also for his master's degree. Arnold G. Kluge, has nearly completed his thesis on the osteology of eublepharine geckos of the genus *Coleonyx*. Robert J. Lavenberg is beginning work on the biology of mesopelagic fishes from the San Pedro Channel off southern California. Allen A. Schoenherr continues his master's research on the ecological distribution of the herpetofauna of the San Gabriel Mountains of California. David B. Wake, who is a NSF pre-doctoral fellow, has virtually completed his osteological study of Western plethodontid salamanders for the M.S. He hopes to expand his research to the entire family for his doctorate. John S. Babel is completing his Ph.D. dissertation on the life history of the round stingray, *Urobatis halleri*. James L. Vial is engaged in work toward a doctorate with emphasis on herpetology, but has selected no problem as yet. During the past year a field team of Arden H. Brame, Jr., who is now finishing up his world checklist of salamanders, A. G. Kluge and R. J. Lavenberg, spent six months in an ecological survey of the herpetofauna of Costa Rica under an NSF grant. Dr. Starrett and Mrs. P. H. Starrett joined them for a month in fieldwork. Mrs. Starrett is nearly finished with her doctorate dissertation, to be submitted for the degree at the University of Michigan. She did her graduate work under the direction of Dr. Charles F. Walker. Dr. Richard E. Etheridge, who recently completed his graduate work at Michigan, is at SC on a N.S.F. Post-doctoral Fellowship and is working with Dr. Savage on problems in lizard osteology. Dr. Savage is engaged in direction of a program of analysis of the biosystematics of the *Bufo boreas* Group under a NSF grant, is working with Dr. John S. Garth of the Hancock Foundation on mesopelagic crusteaca and fishes from the San Pedro Channel, under another NSF grant and jointly with Dr. Starrett continues an active study of the Costa Rican herpetofauna. A recent U. S. Public Health Grant to Dr. Savage will enable the department to set up a modern X-ray laboratory for osteological work, including the latest in soft and hard X-ray equipment. A number of problems in lizard osteology will be investigated under this grant. Dr. Savage also spent a portion of the spring of 1960 in Costa Rica. Mrs. Starrett is active in work on the Costa Rican frogs and together with A. J. Gaudin is participating in the work on *Bufo boreas* and its allies. Etheridge, Kluge and Wake will participate in the X-ray studies of lizard osteology. Lavenberg, who will spend the first 6 months of 1960 in the Arctic Ocean on Ice-Island T-3, returns in October for work aboard the USC research vessel *Velero IV* in the study of the mesopelagic animals of the San Pedro Channel.

## News Notes

DR. GILES W. MEAD, director of the Ichthyological Laboratory of the Smithsonian Institution and a specialist on fishes of the deep seas, became curator of fishes at the Museum of Comparative Zoology of Harvard University on 1 April. DR. F. E. J. FRY of the University of Toronto spent the academic year at Scripps Institution of Oceanography as a Guggenheim Fellow.

The Zoology Department at Tulane University has been augmented by three fish workers. DR. DONALD EUGENE COPLAND, formally with the National Research Council is now Head of the Department of Zoology. Dr. Copeland has conducted research on the physiology of fishes. DR. GERALD E. GUNNING who completed his doctoral research at Indiana University on the sensory basis of homing in sun fishes and DR. FRANKLIN SOGANDARES-BERNAL who is actively investigating the parasites of marine fishes with attention to their distribution as related to that of the hosts have joined the staff.

DR. JOHN S. MECHAM has received a grant from the National Science Foundation for a two year study of the genetical relationships and isolating mechanisms in frogs of the genus *Hyla*. Emphasis in the study will be on the southeastern members of the genus, although some extralimital forms may be included.

*The Society of Systematic Zoology*, at its Annual Meeting with the AAAS in Chicago, December 27–30, 1959, elected the following: President, W. I. FOLLETT, California Academy of Science. President-elect, R. E. BLACKWELDER, Southern Illinois University. Secretary, R. T. ABBOTT, Philadelphia Academy of Science. Treasurer, H. H. HOBBS, University of Virginia. Business Manager of *Systematic Zoology*, J. M. SAVAGE, University of Southern California. Editor of *Systematic Zoology*, L. H. HYMAN, American Museum of Natural History. Program Chairman, C. F. LYTLE, Indiana University.

*The University of Miami Marine Laboratory* announces the availability of financial assistance for graduate (in some cases, undergraduate) students in fisheries and related marine sciences. The John H. Matthews Loan Fund will grant loans of up to $1000. For information, write Dr. C. P. Idyll, Chairman, Department of Marine Sciences, The Marine Laboratory, University of Miami, 1 Rickenbacker Causeway, Virginia Key, Miami 49, Florida.

*The Department of Marine Science of The College of William and Mary* and The Virginia Fisheries Laboratory has announced the availability of graduate assistantships and National Science Foundation stipends for graduate students, advanced undergraduate students, and biology teachers in the field of marine science. A wide spectrum of subjects for interested applicants are available. For detailed information and application blanks write to the Chairman, Department of Marine Science, Virginia Fisheries Laboratory, Gloucester Point, Virginia.

## Meetings

NATIONAL and International meetings of interest to members of the society, and regional meetings of Ichthyological and Herpetological groups will be announced in this section as space permits.

American Society of Ichthyologists and Herpetologists, Western Division, Eugene, Oregon, 13–14 June, 1960

Herpetologists League, Eugene, Oregon, 13–14 June, 1960

American Society of Ichthyologists and Herpetologists, Chicago, Illinois, 17–19 June, 1960

American Society of Mammalogists, Tacoma, Washington, 20–22 June, 1960

Biological Photographic Association, Salt Lake City, Utah, 23–26 August, 1960

American Institute of Biological Sciences, Stillwater, Oklahoma, 28 August–1 September, 1960

American Association for the Advancement of Science, New York City 26–31 December, 1960

Society for the study of Evolution, New York, 26–31 December, 1960

American Society of Ichthyologists and Herpetologists, Austin, Texas, 31 March–2 April, 1961

Tenth Pacific Science Congress, Honolulu, Hawaii, 21 August–6 September, 1961

Sixteenth International Congress of Zoology, Washington, D. C., 21–27 August, 1963

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## Affiliations

The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council, and is an affiliate of the American Association for the Advancement of Science. An annual contribution is made to the publication of the Zoological Record.

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